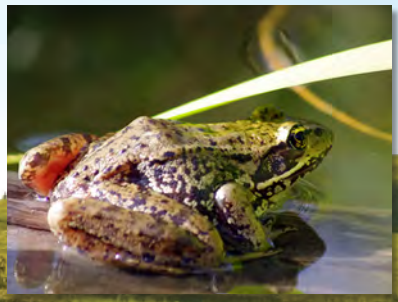
U.S. Fish & Wildlife Service

Strategic Conservation Management

in Oregon's Willamette Valley



Surrogate Species Pilot 1.0

The Power of Partnership

The Willamette Valley is the fastest growing and most densely populated eco-region in Oregon. Strong public and private partnerships are crucial to meet long-term conservation goals. Numerous partners are engaged in active research, conservation, and monitoring programs to improve the status of priority habitats and species in the Valley. These partnerships, the Oregon Department of Fish and Wildlife's Oregon Conservation Strategy, and The Nature Conservancy's Willamette Basin Synthesis Project, provided the foundation for our Strategic Habitat Conservation approach in the Willamette Valley.

We thank the partners that have contributed their valuable time and expertise to this effort. We also thank our other partners who are providing important research, conservation, and monitoring expertise in the Valley. Together, our partnerships can enable a level of conservation no single agency, organization, or individual can accomplish alone.

U.S. Fish & Wildlife Service

OREGON Fish & Wildlife

Oregon Department of Agriculture

Defenders of Wildlife

Metro

Willamette Partnership

The Wetlands Conservancy

The Nature Conservancy
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White-breasted nuthatch
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Executive Summary

The U.S. Fish and Wildlife Service (Service) is using Strategic Conservation Management and a surrogate species approach to conserve important landscape habitats in Oregon's Willamette Valley (Valley). This approach emphasizes the use of surrogate species to monitor, evaluate, and motivate landscape conservation in the Valley. The strategy builds on and seeks to expand existing conservation capacity of the Service and our valued partners. This report, prepared with the input of partners working throughout the Valley, provides an overview of this new approach.

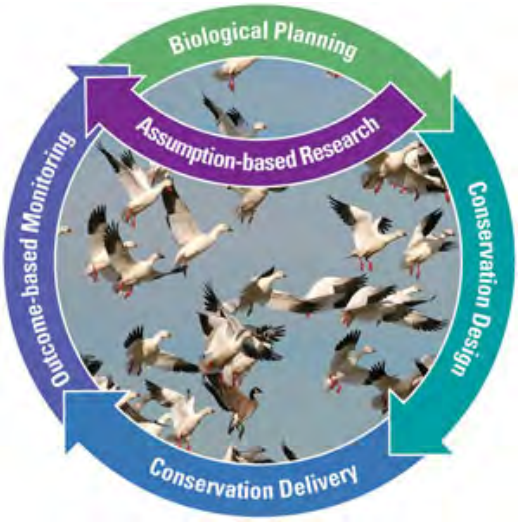
This approach uses surrogate species, as defined by Caro (2010) and others, to help conserve landscapes and the ecological processes that shape and define them. We have divided the Valley into five key habitat types and identified ten surrogate species for these respective habitats. The strategy habitats are Oak Woodland, Grassland, Aquatic, Riparian, and Wetland. The surrogate species for these habitats are Oregon white oak, slender-billed white-breasted nuthatch, Fender's blue butterfly, western meadowlark, American beaver, Bradshaw's lomatium, black cottonwood, northern red-legged frog, Pacific lamprey, and western pearlshell mussel. In addition to representing specific habitat types, these species were also selected to represent the range of surrogate types, such as keystone, indicator, umbrella, and iconic, to better enable an evaluation of this pilot surrogate approach.

Some of our surrogate species, such as Bradshaw's lomatium and Fender's blue butterfly, are umbrella species and will be used to provide direct insight regarding the status of other species on those landscapes. Some of our other surrogates, such as Oregon white oak, black cottonwood, and American beaver, actually represent or determine the overall landscape habitat conditions; inferences can be made for species associated with these habitats based on the status and trends of these surrogates. And last, some of our surrogates are iconic or flagship species, such as western meadowlark or Pacific lamprey; they will be used to infer habitat quality for these and associated species, but they are also used to engage the public and motivate conservation actions.

The selection of these habitats and surrogate species was conducted by a core team of representatives from the Service, the Oregon Department of Fish and Wildlife (ODFW), and key conservation leaders from agencies and organizations working in the Valley. The team took a practical, inclusive, and consensus approach to surrogate species selection by conducting a "meta-review" of existing plans, inventories, and strategies, including the ODFW Oregon Conservation Strategy, the Nature Conservancy's Willamette Valley Synthesis Map, and several other important scientific analyses describing the Valley. This review enabled the team to utilize high quality existing work to make informed selections and to increase the likelihood that surrogate species monitoring and conservation efforts will be implemented on the ground.

Enabling on-the-ground implementation of actions in a cost effective and timely manner was a primary goal of the team. We set biological objectives for each of the surrogate species, which in turn led to identification of priority conservation and monitoring actions. This list of actions, included as an appendix in the report, will be updated and expanded as this document is shared and reviewed by other stakeholders in the Valley. It is our hope and expectation that this approach will lead to an increase in targeted conservation for strategic landscapes, as well as enabling robust evaluations of these conservation efforts.

Introduction



SHC Elements: Biological Planning, Conservation Design, Delivery, Monitoring, and Research.

The U.S. Fish and Wildlife Service (Service) is using a Strategic Habitat Conservation (SHC) approach to conserve fish and wildlife resources and ecological processes at landscape scales (U.S. Fish and Wildlife Service 2008). Elements of SHC include biological planning, conservation design, delivery, monitoring, and research. We are selecting surrogate species for habitats needing conservation, setting measurable biological objectives for these species and habitats, and planning how to achieve these objectives most efficiently using our own resources and by working with partners. This approach provides a framework that facilitates conservation planning, promotes accountability, and supports transparent decisions. It includes monitoring, assessment, and accountability as adaptive management components. The pilot for Region 1 of the Service is the Willamette Valley in Oregon.

This document was developed by the Willamette Valley Strategic Conservation Management Team (Team). Members of this team include representatives of the Oregon Department of Fish and Wildlife (ODFW), Defenders of Wildlife (DOW), Willamette Partnership (WP), The Wetlands Conservancy (TWC), The Nature Conservancy (TNC), Oregon Department of Agriculture (ODA), Metro, and the Service's Oregon Fish and Wildlife Office (OFWO) and Willamette Valley National Wildlife Refuge Complex (WVNWRC). The species and conservation goals identified in the pilot will be reviewed by additional partners that work in the Willamette Valley after the first draft is completed and approved.

Management and Conservation Objectives for the Willamette Valley Surrogate Species Pilot:

1. Identify strategic habitats for the Willamette Valley.
2. Engage partners in choosing surrogate species and developing priority actions for species.
3. Implement and monitor priority actions with partners to evaluate progress toward selected objectives.
4. Build on the quality, ongoing work of our partners and do not "reinvent the wheel."
5. Compare the efficacy of different surrogate types (e.g., keystone, umbrella, etc.).
6. Use the Strategic Conservation Management approach and surrogate species to advance other conservation efforts, including urban refuges and engaging youth in conservation.
7. Make this document accessible, enjoyable to read, and implementable for our many and varied partners in the Valley.

Meta-Review Approach

During the last decade there have been many strategic planning efforts in the Willamette Valley. Recognizing the multitude of these recent and ongoing, science-driven planning efforts, the Team concluded it would be most efficient to use them to inform the selection of surrogate species for this pilot. Consequently, the Team used a "meta-review" approach to select surrogate species and priority landscapes for the Valley.

Some of the past and current planning efforts we reviewed included the following:

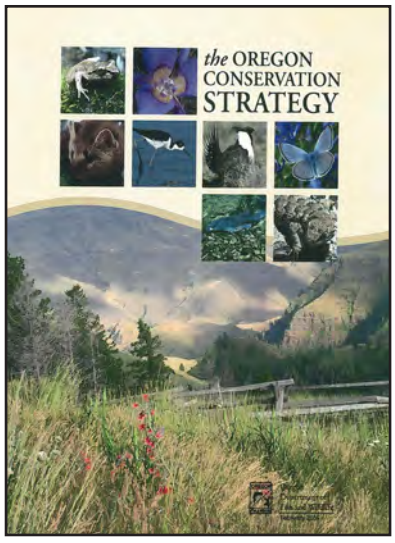
- ODFW's Oregon Conservation Strategy (OCS, ODFW 2006)
- TNC's Willamette Basin Synthesis Project (2012), which incorporated:
    - Willamette Valley Ecoregional Assessment (Floberg et al. 2004)
    - Willamette River Basins Alternative Futures Project (Pacific Northwest Ecosystem Research Consortium 2002)
    - ODFW's OCS
    - TWC's Priority Wetlands
    - Oregon Biodiversity Project
- Preliminary output from the Service's Willamette Valley Conservation Study (ongoing)
- Willamette Valley National Wildlife Refuge Final Comprehensive Conservation Plan (CCP; U.S. Fish and Wildlife Service 2011)
- Tualatin National Wildlife Refuge CCP (U.S. Fish and Wildlife Service 2013)
- The Biodiversity Initiative (Nelson et al. 2006, U.S. Forest Service 2011)
- The Willamette Restoration Initiative's Willamette Restoration Strategy (Jerrick 2001)
- The Regional Conservation Strategy for the Greater Portland-Vancouver Region (Intertwine Alliance 2012)
- Metro's corridor assessment tool (in progress)
- Recovery plans, listing determinations and critical habitat designations, and five-year reviews for Willamette Valley listed species

There are many more efforts than those listed here. These efforts represent a solid foundation upon which to base the selection of surrogate species to help guide conservation efforts in the Valley. We were careful not to repeat or work at cross purposes with these efforts, but rather utilize them for this pilot. A summary of the efforts most similar to the surrogate species pilot are highlighted in Table 1 and the following section.

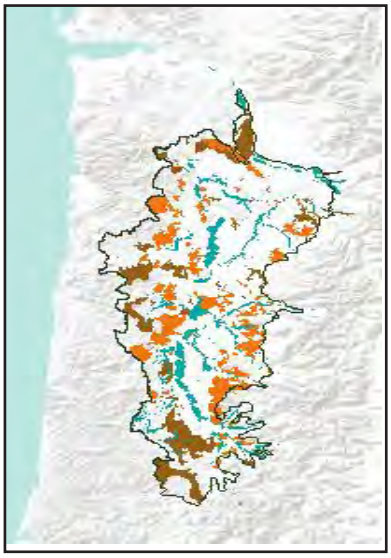
Table 1. Strategy habitats and species for four Willamette Valley planning efforts.

Effort	Last Update	Strategy Habitats											Priority Species
		Aquatic / Riverine	Columbia River	Aquatic Connection	Riparian - Combined	Riparian – Bottomland Forest	Riparian – Shrubland	Upland - Combined	Upland – Grassland	Upland – Oak Savanna	Upland – Oak Woodland	Wetlands	Integrated	Number of Focal Species / Guilds
OCS	2006	X			X				X		X	X		44
WV Synthesis Map	2012	X		X	X			X					X	123
The Biodiversity Initiative	2011	X	X		X				X		X	X		17 / 2
WVCS	2013	X				X	X		X	X	X	X		20

Summary of Recent Efforts to Identify Strategy Habitats and Species



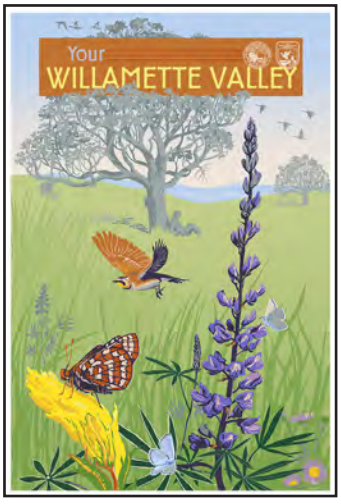
Oregon Conservation Strategy: The OCS is the State's wildlife action plan. It was developed by ODFW in 2006 and is currently being updated. Although prior to this effort there were many species-specific conservation strategies, it was the first overarching statewide strategy for conserving Oregon's fish and wildlife. The OCS is a broad strategy for all of Oregon, offering potential roles and opportunities for residents, agencies and organizations. It emphasizes proactively conserving declining species and habitats to reduce the possibility of future Federal or State listings and regulations. Importantly, it establishes the basis for a common understanding of the challenges facing Oregon's fish and wildlife and provides a shared set of priorities for addressing the State's conservation needs. The OCS includes a detailed description of the Willamette Valley, its strategy habitats, and identifies 44 priority species (ODFW 2006) in the Valley. The five strategy habitats in the OCS for the Valley include freshwater aquatic, grassland, oak woodland, riparian, and wetland habitats.



TNC Conservation Opportunity Areas

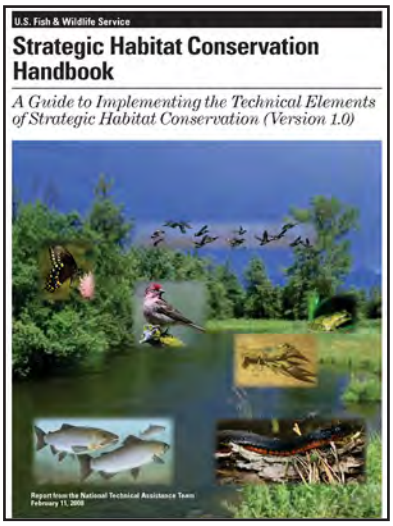
Willamette Basin Synthesis Map: The Nature Conservancy's Willamette Valley Synthesis Map was developed in 2008, updated in 2012, and will continue to be updated as needed. The primary goal of the project is to delineate priority terrestrial and freshwater sites where investment in conservation or restoration would best contribute to the health of historically significant habitats, the survival or recovery of imperiled species that depend on the habitats, improve floodplain connectedness, and overall watershed health. The Nature Conservancy combined maps produced by separate conservation planning efforts (page 3) to generate "Conservation Opportunity Areas" in the Valley. They facilitated a process to evaluate and reconcile discrepancies, resulting in the Synthesis Map. Five Strategy Habitats identified for the Willamette Valley Synthesis Map include aquatic, aquatic connection, riparian, upland, and integrated (mixture of upland and aquatic/riparian) habitat. One hundred twenty-three target species were identified in the Valley.

The Biodiversity Initiative: In 2004, the U.S. Forest Service launched a Biodiversity Initiative to help integrate complex biodiversity concepts into natural resource management processes. This initiative had two main objectives: (1) to learn from the diverse natural resource stakeholders what major challenges they face in managing for biodiversity; and (2) to develop a set of priority management tools or products in direct partnership with interested collaborators to help meet those challenges. Oregon Department of Fish and Wildlife staff, in consultation with other experts, selected species monitoring priorities in 2006 and 2007 for the Biodiversity Initiative. Their selection was part of the overall biodiversity monitoring strategy proposed by an interagency work group in 2006 and 2007. In the Willamette Valley ecoregion, species were selected for Columbia River, grassland, oak woodlands, riparian, wetlands, and freshwater aquatic habitats. Seventeen species and two guilds were selected as monitoring priorities.



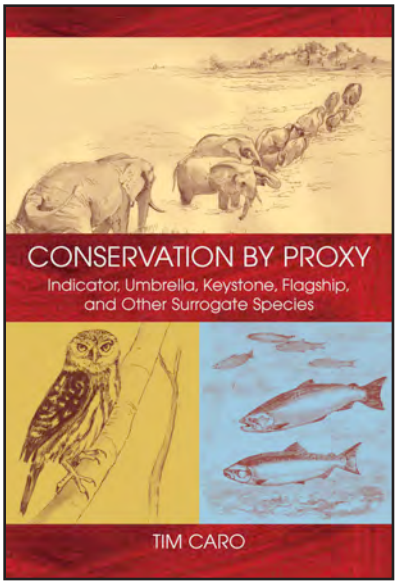
Willamette Valley Conservation Study: The Service began the WVCS in 2011. It is a project of the America's Great Outdoors Initiative. This study identified seven strategic habitats and a preliminary list of 20 priority species (seven representing habitat types and 13 that also were considered a priority for management). The strategy habitats included: prairie, oak savanna, oak woodland, bottomland hardwood forest, riparian shrublands, wetlands, and riverine habitats. Eighteen of the 20 tentatively selected species are among the 44 identified by ODFW in the OCS (ODFW 2006). Two additional species also were identified to potentially represent bottomland hardwood forest and riparian shrublands.

Surrogate Species Selection



We are using the surrogate species approach to maximize the use of limited resources and to focus these resources on conservation efforts that have the greatest potential to conserve habitat and species in the Willamette Valley. Surrogate species are defined by Caro (2010) as "species that are used to represent other species or aspects of the environment to obtain a conservation objective." He divided surrogates into three categories: (1) those that help locate areas of conservation significance; (2) those that help document the effects of environmental change on biological systems; and (3) species employed in public-relations exercises to promote understanding of conservation problems and to raise money (Caro 2010). There are many types of surrogate species, such as keystone, flagship, and umbrella species (Appendix A). As conservation biologists, we are instinctively drawn toward selecting surrogate species that seem to directly represent the greatest number of native and rare species (Simberloff 1998). However, there is uncertainty in the ability to select surrogates that are truly representative of other species or habitat types (Boogert et al. 2006, Favreau et al. 2006, Lindenmayer and Likens 2011, Che-Castaldo and Neel 2012). There are few areas where studies have clearly demonstrated that a surrogate species or species-group represented the distribution of other taxa or the responses of other taxa to environmental change (Fleishman et al. 2001, Niemi and McDonald 2004, Caro 2010), but many scientists have made useful recommendations of how to overcome this challenge. For example, Lewandowski et al. (2010) and Andelman and Fagan (2000) evaluated the relative utility of different types of surrogate approaches under differing ecological settings. Chase et al. (2000) recommended selecting species that represent the broad range of a targeted habitat type rather than narrow niche specialists, while others (Hitt and Frissell 2004, Weins et al. 2008, Murphy et al. 2011) provided suggestions for applying a surrogate approach to species already protected under the Endangered Species Act.

Another approach in surrogate species selection is to consider iconic, flagship, or charismatic species that are most likely to garner important partner and public support in order to achieve our ultimate conservation objectives (Barua 2011). This consideration is warranted because, on a larger scale, surrogates and non-target species within the same habitat type face the similar threat of habitat loss and degradation. Our approach emphasizes the commonalities of species' conservation needs. Generally, both surrogates and most non-target, native species can benefit from efforts to maintain and increase native habitat or mimic natural ecosystem processes within their represented habitat types. Some non-target species will immediately and directly benefit from management actions aimed at surrogate species. For other species, these efforts will not provide immediate, measurable benefits, but will instead serve as a stepping stone to also improve or maintain their habitat.



The wide variety of approaches helped drive our decision in the Willamette Valley to use the "meta-review" approach and our reliance on the broad experience of the Team to select potential surrogate species.

The Team adopted the ODFW (2006) strategy habitats and selected species to represent those habitats. When selecting surrogate species we considered the Willamette Valley focal species identified by ODFW (2006), the Willamette Basin Synthesis Project (TNC 2012), the Biodiversity Initiative (U.S. Forest Service 2011), and the WVCS (ongoing). We also considered any additional species nominated by the Team. The following questions, developed after Favreau et al. (2006), were considered in our selection of species as surrogates:

1. Is the species strongly associated with the habitat type for which it is a surrogate (Ozaki et al. 2006)?
2. Is it a proxy for other species in the same habitat type?
3. Is it a proxy for the habitat's ecological processes (Ricklefs et al. 1984)?
4. Does it have large spatial needs that encompass the needs of other species (Andelman and Fagen 2000)?
5. Do the species' population dynamics represent changes in the larger landscape?
6. Will the species be affected by climate change similarly to other species in the landscape?
7. Are invasive species, pests, and pathogens impacting this species similarly to other species in the landscape?
8. Is this species currently monitored or readily monitored using standard techniques?
9. Do we have sufficient data on the species' biological requirements and distribution?
10. Does this species have public interest or appeal? Can it be used to engage youth and to promote conservation near urban areas?
11. Does it have a high probability of persistence (Andelman and Fagen 2000)?
12. Does it have high utility as a surrogate – e.g., can it leverage resources?

We are using this pilot to evaluate the application of several surrogate species approaches, such as keystone, indicator, umbrella, and iconic species. Some species are better potential proxies for other species or ecological processes than are others. However, we only selected species as surrogates if they were also readily monitored, had partner support, or had high ability to leverage resources. We also considered if partners had ongoing projects or plans to monitor certain species. Consideration was also given for some species that, despite low levels of current public interest, have need for increased conservation-oriented attention. The Team received concurrence from ODFW for all surrogate species selections and priority actions for which ODFW has primary management authority.

Willamette Valley Strategy Habitats and Surrogate Species

Bounded on the west by the Coast Range and on the east by the Cascade Mountains, this ecoregion encompasses 3,397,106 acres (ac; 1,374,766 hectares [ha]) in the Willamette Valley and adjacent foothills. The Valley is a long, level alluvial plain with scattered groups of low basalt hills. Elevations on the Valley floor are about 400 feet (ft; 121.9 meters [m]) at the southern end near Eugene, dropping gently to near sea-level at Portland. The climate is characterized by mild wet winters and warm dry summers. Fertile soil and abundant rainfall make the Valley the most important agricultural region in the State (ODFW 2006).

The majority of the Willamette Valley ecoregion has been altered by development. The Valley contains urban areas nestled within productive farmland. Traditional industries and high technology contribute to the vibrancy of the economy. With Interstate 5 running its length, the Willamette Valley's economy is shaped by the transportation system and the flow of goods. With nine of the ten largest cities in Oregon, the Willamette Valley is the most urban, and fastest-growing, ecoregion in Oregon. Pressure on Valley ecosystems from population growth, land-use conversion, and pollution is likely to increase. About 96 percent of the Willamette Valley ecoregion is privately owned, and voluntary cooperative approaches are key to long-term conservation. The greatest conservation issues in the Valley include land use changes, altered disturbance regimes (both fire and floodplain function), and invasive species. In addition to addressing these issues, some conservation needs for the Valley include maintaining and restoring fish and wildlife habitats in urban centers and conserving, restoring, and reconnecting high value habitats (ODFW 2006).

Strategy Habitats

Strategy Habitats in the Valley, which are habitats of high conservation priority, helped form the organizational basis for this surrogate pilot project. These habitats are based on ODFW's 2006 OCS and include the following:

- Oak woodlands,
- Grassland (including oak savanna),
- Aquatic,
- Riparian, and
- Wetlands (including all freshwater wetland and wet prairie).

Prior to development, these strategy habitats occupied the majority of the Willamette Valley (Figure 1a). Currently, there are 46 distinct ecosystems in the Willamette Valley as identified by U.S. Geological Survey (USGS) National Gap Analysis Program (GAP) Land Cover dataset (2011). These data were aggregated into the following categories: disturbed/modified, developed, and the strategy habitats identified by the 2006 OCS for the Valley (Figure 1b). Although implementation of conservation actions in many places in the Valley would benefit strategy habitats and their species, a focused effort in specific priority areas will increase the likelihood of long-term success over larger landscapes, improve funding efficiency, and promote cooperative efforts across ownership boundaries (ODFW 2006). Both the 2006 OCS and TNC's Willamette Basin Synthesis Project identified high priority areas as "Conservation Opportunity Areas" (COAs) (Figure 1c). These COAs are areas where landscape-level fish and wildlife conservation goals would be best met (ODFW 2006) in the Willamette Valley.

The COAs identified by TNC incorporate the majority of COAs identified by the 2006 OCS while identifying additional areas for conservation and enhancement opportunities (Figure 1c). The Nature Conservancy's COAs were developed to guide voluntary, non-regulatory action, and are supported by committed partners as a strategic framework for focused efforts and conservation actions in the Willamette Valley. The COAs developed by ODFW also help guide voluntary actions for species and contain some areas not included in TNC's COAs. Thus, we recommend consideration of both COAs and prior project locations to plan and site new projects within the Willamette Valley to ensure long-term success and provide connectivity among habitats.

The following discussion presents an overview of the priority habitat types and the proposed surrogate species that occur within them.

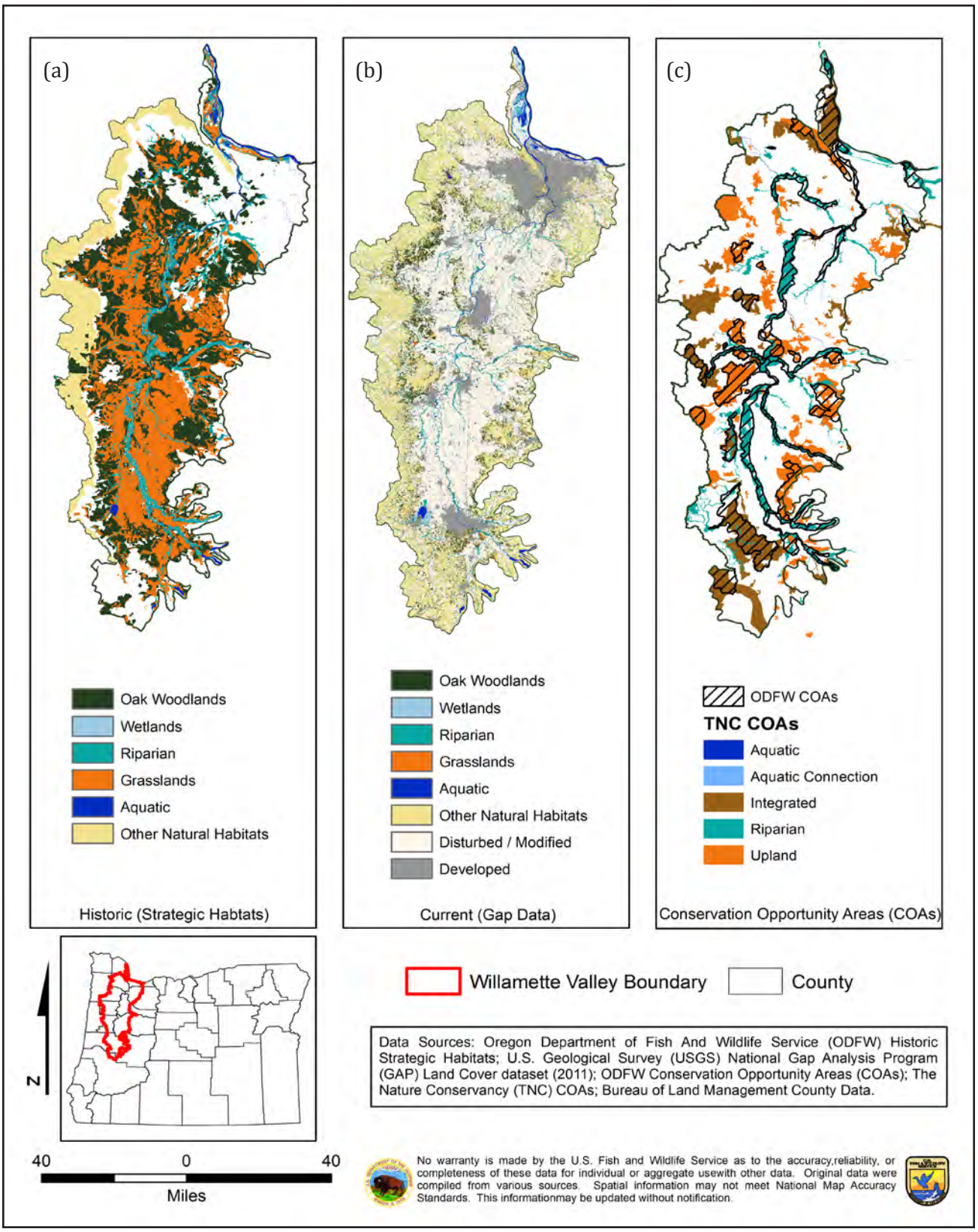


Figure 1. Willamette Valley maps, including: (a) Historic distribution of strategy habitats (ODFW 2006); (b) Current distribution of strategy habitats and other habitat types where conservation and monitoring actions may be implemented; and (c) Overlay of Conservation Opportunity Areas identified by ODFW (2006) and the Synthesis Map (TNC 2012).

Oak Woodlands

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Oak woodlands have a continuous or open canopy dominated by Oregon white oak (*Quercus garryana*) and a relatively open understory that contains shrubs, grasses, and wildflowers. Oak woodlands grade into oak savannas, which are addressed separately in the grassland section (Figure 2). In the Willamette Valley, oaks were most common on flat to moderately rolling terrain, usually in drier landscapes, and often found in a mosaic of prairies, oak savanna, and riparian habitats throughout the Valley floor and low elevation slopes. Oaks are used by more than 200 species of native wildlife in the region. The woodland canopy and its foliage offer shade and hiding cover for various species, while fallen leaves provide a source of organic litter, an important microhabitat for amphibians and reptiles (Vesely and Tucker 2004). Some of the ODFW OCS (2006) species associated with oak woodlands include the Western gray squirrel (*Sciurus griseus*), acorn woodpecker (*Melanerpes formicivorus*), and the slender-billed white-breasted nuthatch (*Sitta carolinensis aculeate*).

Oak woodlands once covered 400,000 ac (161,875 ha) in the Willamette Valley, but now the Valley has less than seven percent of its historic oak woodlands. Today, oak woodlands usually exist in small isolated pockets surrounded by other land-uses, such as development or agriculture. This habitat has been impacted by conversion to other land uses, invasive species, and vegetation changes due to fire suppression (ODFW 2006). Oak habitats need to be maintained through fire, which removes small conifers and maintains a low to moderate shrub cover. Because much of the remaining oak woodlands are in private ownership and maintenance of these habitats requires active management, cooperative incentive-based approaches are crucial to conservation (ODFW 2006).

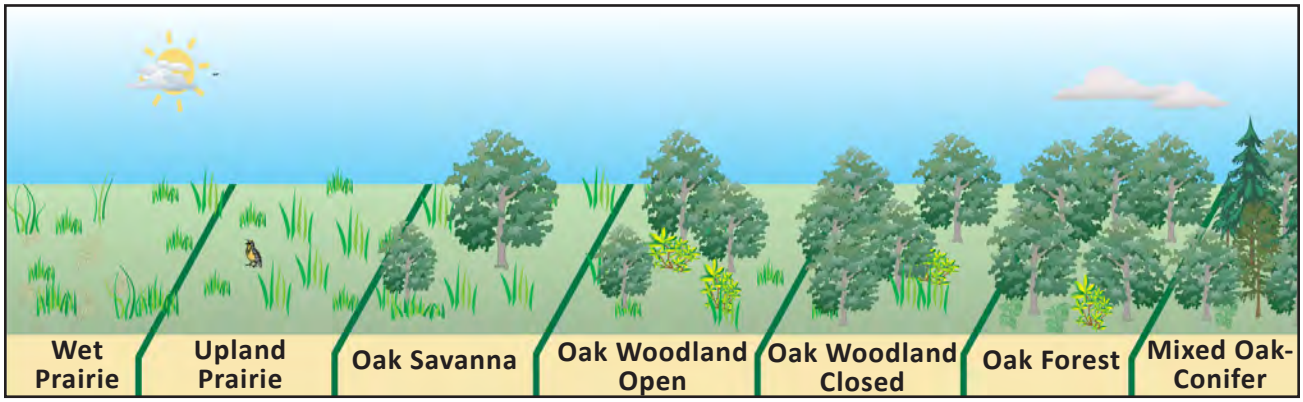

Figure 2. Gradient of Prairie-Oak Habitat Types, adapted from Altman and Stephens 2012.

Surrogate Species in Oak Woodlands

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Oregon white oak: is the dominant species in the Willamette Valley's oak woodlands and is an ***iconic*** and ***engineering*** surrogate species (Boogert et al. 2006). The **primary objective** in selecting it as a surrogate species is to better enable oak woodland conservation and to monitor and evaluate the success of these oak conservation efforts.

Oaks are important ecologically at individual tree and woodland scales (Figure 3; Vesely and Tucker 2004). Diversity of bird species is often higher in oak forests than in adjacent conifer forests (Cole 1977). Even scattered legacy trees benefit oak savanna-associated bird populations (DeMars et al. 2010). Oaks are also significant culturally. Historically, Kalapuya Tribes in the Valley harvested, prepared, and stored acorns in the fall and manufactured oak into tools (Vesely and Tucker 2004). Small oak woodlands can provide periodic income from timber sales, improved recreation opportunities and wildlife viewing, a firewood supply, shade for livestock in pastures, and enhanced landscape aesthetics.

Oregon white oak can live up to 500 years and may persist as a climax species on sites prone to drought or naturally occurring fire (Vesely and Tucker 2004). Oaks grown in unmaintained habitat are tall with ascending branches and narrow crowns, while oaks grown in open conditions have wide, spreading branches and large crowns. Historically, natural fires and frequent burning by Native Americans maintained expansive prairies and open oak savannas (Habeck 1961, Thilenius 1968). In areas not cleared for agriculture, fire suppression resulted in the succession of oak savannas and prairies

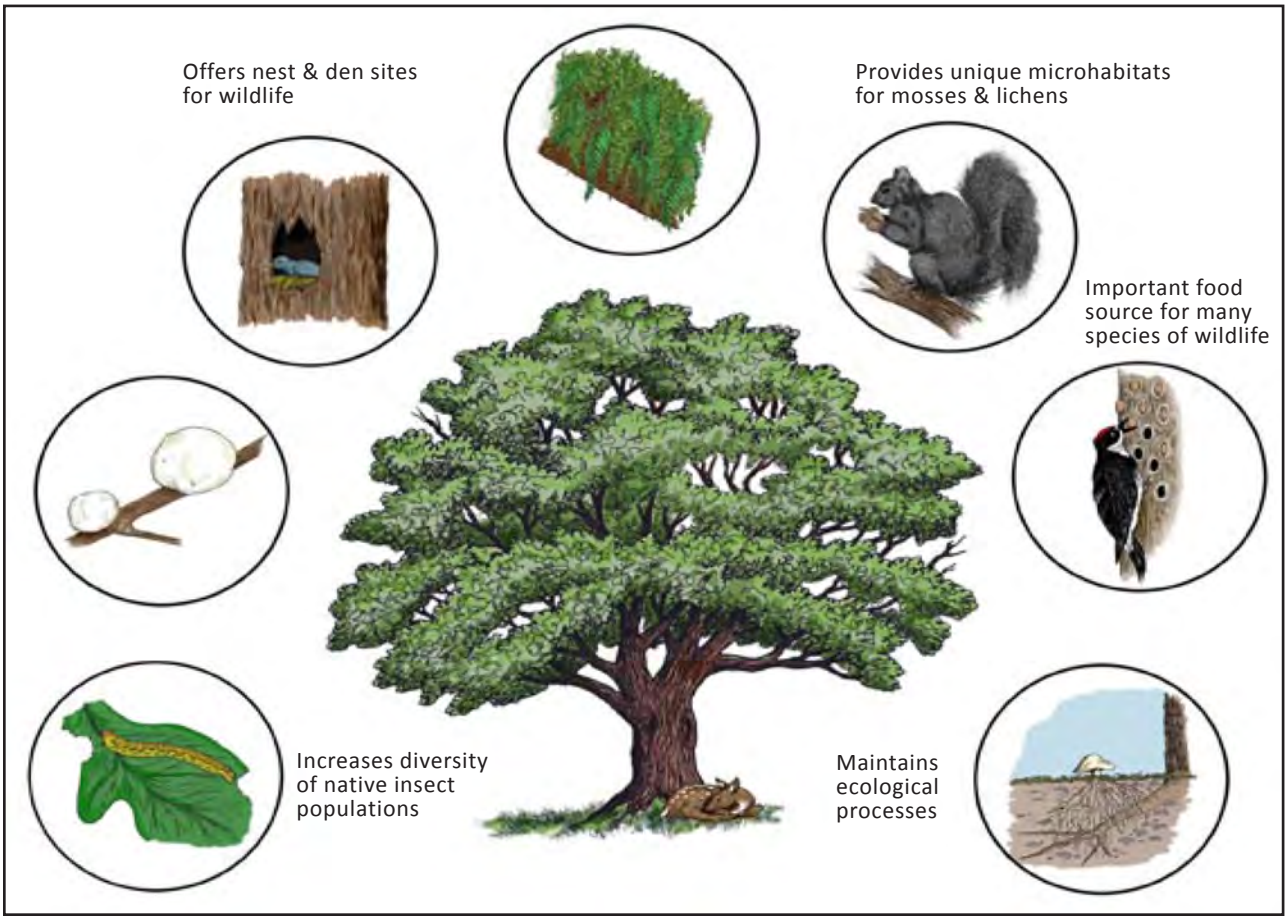
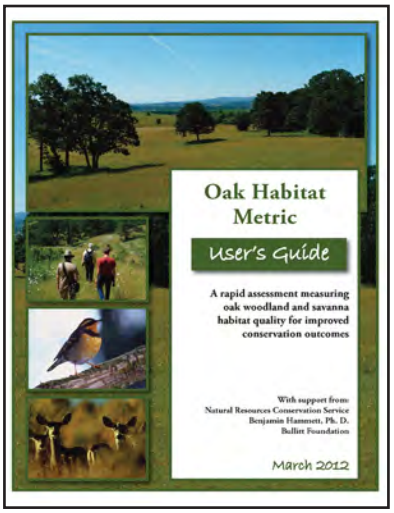


Figure 3. Oregon white oak's contribution to the biological richness (Vesely and Tucker 2004).

into dense oak woodlands. Future persistence of oak trees is dependent on periodic fire or active management as a "surrogate" for fire.

Many partners are already engaged in strategic habitat conservation in the Valley through landscape-level oak restoration efforts. For example, TNC invests in sound science and planning efforts, works to improve land use policies, and protects and restores oak woodlands. The Service's WVNWRC implements restoration efforts to reverse the succession of oak woodlands toward Douglas-fir and maple forests, and their work was showcased through the Oregon Oak Communities Working Group (Hagar 2012). Development and implementation of best management practices for oak woodlands, and specifically for legacy trees, will help landowners incorporate conservation of this species and oak woodlands into long-term land management.



We selected Oregon white oak as a surrogate species because it creates a variety of habitat and resource conditions that supports a multitude of other species (Boogert et al. 2006). Using the Willamette Partnership's "Oak Habitat Metric" to measure current or baseline conditions as well as the conservation benefits of active oak management will provide quantitative scientific information about the long-term trajectory of this species and its habitat. This ***iconic*** species can also readily engage youth and urban populations, as it is often planted through programs such as Friends of Trees, and it occurs widely on refuges near urban areas.

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Slender-billed white-breasted nuthatch: is one of two white-breasted nuthatch subspecies in Oregon and is a ***management indicator*** species. The **primary objective** in selecting this species as a surrogate is to provide insight into the effectiveness of the oak habitat conservation efforts described above for nuthatches and other bird species that utilize similar niches.

This subspecies is rare across most of the Valley, but can be locally common in stands of oak, mixed oak conifer woodlands, and nut orchards (Hagar 2003). In the Valley, they are found in open oak stands dominated by older trees with an open growth form, which provides more habitat for arthropods and more foraging habitat for nuthatches (Jackson 1979). Oaks in open stands also contain more nesting cavities than oaks in dense oak stands (Gumtow-Farrior 1991). Unlike most North American passerines, nuthatches maintain close pair bonds and occupy the same territories year-round (Hagar 2003). This species is easily detected from late summer to early spring when they are most vocal. It is a suitable surrogate species because it depends on mature oak stands that require a number of habitat management actions (e.g., thinning, conifer removal, application of fire) that benefit other species adapted to this open system.

Limiting factors for nuthatches in the Valley include habitat loss (i.e., fewer mature oaks and nesting cavities) due to development and conversion to oak-conifer woodlands. Some of the conservation actions identified for this species include: maintaining large oaks over 22 inches (in; 55.9 centimeters [cm]) diameter at breast height (dbh) and developing nest box programs for cavity habitat in the short-term (ODFW 2006), working with landowners to incorporate conservation of this species and oak woodlands into long-term land management commitments, and assessing factors that may account for loss of pairs at formerly occupied sites (WDFW 2005). Although there are few actions aimed specifically at nuthatch conservation at this time, the species and many others indirectly benefit from oak woodland restoration and maintenance in the Valley.

Willamette Valley Surrogate Species Pilot Oak Woodland Case Study: Metro Connecting Urban Communities with Oak Woodland Restoration

Metro is working to protect oak habitat throughout the Willamette Valley within the region's voter-approved Natural Areas Program. The program protects, enhances, and restores landscapes, and supports hundreds of community projects. Metro is committed to an adaptive management strategy at each of its sites and takes action in re-establishing oak habitats through planting of new trees or enhancement of areas by oak "release." Metro's oak "release" strategy eliminates competitors of oaks, minimizes invasive species, and maintains native plant biodiversity. Metro's science and stewardship team works with contractors, partners and volunteers to achieve these goals.

In 2001, Metro purchased the 250 ac (101 ha) Graham Oaks Nature Park in Wilsonville, and is working with partners to restore the area from its former agricultural setting back to oak habitat. Metro has planted wildflowers, grasses, trees, and shrubs historically found in the Valley, including thousands of oak trees. Graham Oaks is regularly used by students of the West Linn-Wilsonville School District as a learning laboratory and volunteer site stewards help maintain the nature park.

Metro also owns property in the Willamette Narrows area near West Linn that spans more than 500 ac (202 ha) and contains some of the largest known contiguous expanses of Oregon white oak trees in the Portland area. Douglas fir (*Pseudotsuga menziesii*) and Oregon ash (*Fraxinus latifolia*) were shading out the Oregon white oak and other plants that are part of the oak community. Metro has selectively sprayed and hand-removed non-native plants and felled trees that stood between the oaks and the sun, freeing up nutrients and light for oaks and other native plants.

Metro uses a volunteer-supported wildlife monitoring program to monitor regional natural areas. By focusing on indicator species, such as amphibians and birds, volunteers provide data to help Metro's Science and Stewardship Team gauge the progress of its restoration efforts and track the effects of public use on wildlife. Bird surveys at the Willamette Narrows Natural Area demonstrated that tree thinning had an immediate positive response on the number of bird species within the first year of oak "release." These monitoring results and others like it demonstrate that Metro's restoration and management efforts are benefiting a suite of species, plants and animals associated with Oregon white oak habitats.

Metro

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Grasslands

© BLM West Eugene Wetlands Staff

Grasslands, or upland prairies, are dominated by grasses, forbs, and wildflowers. Grasslands have well-drained soils and often occur on dry slopes. They are similar to wet prairies in structure and share some of the same prairie-associated plants and animals. Oak savannas are grasslands with scattered Oregon white oak trees, generally only one or two trees per acre (per 0.4 ha). Oak trees in savannas are usually large with well-developed limbs and canopies (ODFW 2006). Native grasslands are one of the most imperiled habitats in the western United States. In Oregon, the greatest loss of grasslands has been in valley bottoms and foothills where they have been impacted by conversion to agriculture, development, and invasive plant species. Disruption of historical fire regimes has allowed for shrubs or trees to encroach, replacing grasslands with forest. In addition, some foothill grasslands have been converted to forests through tree planting. The Willamette Valley has lost about 99 percent of its native grasslands (ODFW 2006), and remaining grasslands are particularly fragmented and isolated. Since much of the Willamette Valley is privately owned, the efforts of private landowners are key to the survival of grassland species.

Surrogate Species in Grasslands

© Matt Benotsch / TNC

Fender's blue butterfly: (FBB; *Icaricia icarioides fenderi*) is an ***umbrella*** surrogate for several upland prairie species (e.g., lupine [*Lupinus* sp.], Willamette daisy [*Erigeron decumbens* var. *decumbens*], western meadowlarks [*Sturnella neglecta*], and golden paintbrush [*Castilleja levisecta*]). The **primary objective** in selecting this species as a surrogate is to help conserve other species that also occur in this prairie habitat.

Fender's blue butterflies are endemic to the Willamette Valley and their current range is from Eugene north through Washington County, to southwest of the Portland area. Fender's blue butterfly uses upland prairie and oak savanna habitat that lacks dense canopy cover and contains both larval host plants (lupine) and available forbs for adult nectar sources. Fender's blue butterfly will also utilize wet prairie for nectar sources and dispersal habitat. It is an endangered species with both designated critical habitat (U.S. Fish and Wildlife Service 2000, 2006) and a final recovery plan (U.S. Fish and Wildlife Service 2010).

Fender's blue butterfly recovery requires high quality prairie habitats for all life stages. Therefore, many of the management actions aimed at maintaining and improving their habitat will benefit a variety of other grassland and oak savanna species. The recovery goal for FBB is to have functioning networks of butterflies in each of the three recovery zones. A functional network is at least three subpopulations supported by a defined minimum habitat patch size (currently 15 ac [6 ha]) and separated by no

more than the maximum estimated dispersal distance (currently defined as 1.2 miles [mi]; 2 kilometers [km]). If subpopulations are further apart than the maximum separation distance, they require suitable "stepping stone" habitat within 0.62 mi (1 km) of natal lupine patches to contribute to a functioning network.


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Biologists from Federal and state agencies and private conservation organizations are engaged in active research, conservation, and monitoring programs to improve the status of FBB. Recent research has focused on population viability analysis, metapopulation dynamics, response to habitat restoration, and monitoring protocols (U.S. Fish and Wildlife Service 2010 and references within). A small sample of ongoing conservation efforts for this species include: the development of a prairie and FBB habitat calculator by the Willamette Partnership, Marys River Watershed Council's Wren Nectar Network, TNC's Willow Creek, Coburg Ridge, and Yamhill Oaks preserves, final Habitat Conservation Plans (HCP) for Benton and Yamhill Counties and a draft HCP for Yamhill County Soil Water Conservation District and ODOT, Safe Harbor and Partners for Fish and Wildlife Agreements with private landowners in the Valley, and ongoing conservation efforts at Baskett Slough NWR, Bureau of Land Management (BLM)'s Fir Butte and Oak Basin sites, Army Corp of Engineer's (COE) Fern Ridge Reservoir, and Green Belt Landtrust's Lupine Meadows preserve.


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Western meadowlark: is both a ***management indicator*** and – as Oregon's official State bird – an ***iconic*** surrogate species. The **primary objective** in selecting this species as a surrogate is to provide insight into the success of prairie and grassland conservation efforts.

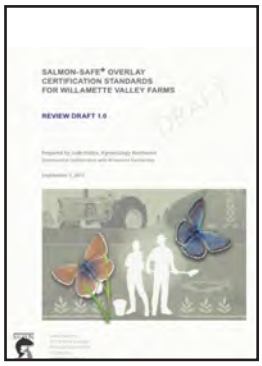
The western meadowlark is a rare breeding species in the north Willamette Valley, uncommon in the central and southern Valley, and locally common in the southeastern part of the Valley between Brownsville and Coburg and around Fern Ridge (Altman 2003). It is a yearlong resident in the Valley inhabiting grassland and pasture. Here, their optimal breeding habitat in is lightly grazed pastures or fallow fields with grass height of 1-2 ft (0.3-0.6 m) and shrub or tree cover less than 10 percent. They will use cultivated grass fields for escape cover and sometimes for nesting, but these areas must also be near suitable foraging habitat (Altman 2003). They nest in late April through early July their territories range from 4.8 to 35 ac (1.9 to 14 ha) in the Valley (Altman 1999). This species' call is easily detectable from long distances in the spring and summer and conspicuous perches make visual detection easy year-round. A recent study at 544 point count stations throughout the Willamette Valley reported a 59 percent decline in detections of meadowlarks between 1996 and 2008 (Myers and Kreager 2010). Factors contributing to the species' decline in the Valley include habitat degradation, trampling of nests from practices like mowing, development of habitat, and increased predation from feral and domestic cats. Conservation in the Valley is complicated by their need for relatively large areas to accommodate their large territories (Altman 2003).

There are few conservation efforts occurring that are targeted solely at meadowlarks. However, there are numerous actions occurring for a suite of grassland species that directly or indirectly benefit this species. Many of the actions that benefit FBB also help this species, although meadowlarks require a larger landscape, and it is anticipated that other prairie projects can be efficiently modified to also implement meadowlark-related management priorities. In their strategy, ODFW identified the following conservation priorities for western meadowlarks: maintain or restore grassland habitat (especially those over 100 acres [40.5 ha]), increase plant diversity for greater insect diversity, control

key non-native plants, and minimize disturbance during the breeding season (April 15 to July 1) at known nesting areas. Monitoring of western meadowlarks, as well as most avian species has mostly been project-specific. Information on this species' status and population trends is somewhat captured with Breeding Bird Surveys.

Willamette Valley Surrogate Species Pilot Grasslands Case Study #1: Prairie Calculator, Conservation Agreements, and Incentives

The Willamette Partnership is working with partners to develop an Upland Prairie Calculator that will assess habitat quality in a rapid and standardized manner. The assessment tool uses Fender's blue butterfly (FBB) recovery criteria as ecological benchmarks and will help measure and track progress towards species recovery as well as determine impacts and mitigation currency for conservation banking purposes.



Building from this calculator and the Service's programmatic Safe Harbor Agreement for FBB, the Service, Willamette Partnership, and Salmon-Safe are piloting an Incentives Trifecta approach to private landowner conservation of FBB. The Trifecta approach involves: (1) eco-certification; (2) generating ecosystem service credits; and (3) regulatory assurances. Using Salmon-Safe+ (a farm certification standard with management practices aimed specifically at FBB conservation) and the Prairie Calculator, Willamette Valley landowners will be eligible for Safe Harbor for FBB. The Prairie Calculator will be used to measure the conservation benefits produced by landowners; those benefits may be translated to ecosystem service credits and potentially used as offsets under a conservation banking program in the future.

Willamette Partnership

Grasslands Case Study #2: Willow Creek Preserve/TNC Hayfield Meadows

The Nature Conservancy protects and manages the Willow Creek Natural Area Preserve in Eugene, Oregon, under lease agreements with private landowners. The preserve is part of the West Eugene Wetlands, an area protected through a unique partnership between local, state and Federal agencies, the local community and The Nature Conservancy. The Nature Conservancy has implemented restoration of abandoned agricultural areas adjacent to extant FBB populations at the preserve in an area known as "the Hayfield." Restoration efforts at the Hayfield include herbicide treatments, mowing, and plantings of Kincaid's lupine (*Lupinus oreganus*), host plant for FBB, and a diversity of native nectar species. They have, in partnership with Washington State University, documented exponential growth of the FBB population in this field since restoration efforts began. Lessons learned from their restoration efforts at Hayfield and other areas will be helpful in guiding future restoration efforts for FBB.

The Nature Conservancy
Protecting nature. Preserving life.®

Wetlands

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Wetlands are covered with water during all or part of the year and these habitats are highly diverse. Permanently wet habitats include backwater sloughs, oxbow lakes, and marshes while seasonally wet habitats include seasonal ponds, vernal pools, and wet prairies. Wetlands provide important habitat for migrating and breeding birds, mammals, amphibians, and reptiles. Additionally, floodplain wetlands and backwater sloughs and swamps are important rearing habitats for juvenile salmon. Wetlands improve water quality by trapping sediments and toxins, recharge aquifers, store water, and reduce the severity of floods. Restoration and careful management of wet meadow systems and other wetlands can increase sustainable production of forage for livestock and increase late-season stream flows (ODFW 2006). Limiting factors to wetland habitats include habitat loss, water availability, degraded water quality, and invasive species. In the Willamette Valley, a high percentage of low-elevation and valley bottom wetlands have been lost or degraded through diking and draining. Almost all remaining wetlands in the Valley have been degraded to some degree by altered water regimes, pollution, and invasive plants and animals (ODFW 2006).

Surrogate Species in Wetlands

© Helen Haden

American beaver: (*Castor canadensis*) is an ***engineering keystone*** and ***iconic*** surrogate species (Caro 2010). Engineering keystones create habitat and resources that support a multitude of other species in ecosystems (Boogert et al. 2006). Ecosystem engineering by organisms is either autogenic, where organisms themselves are part of the engineered habitat (e.g., trees or oyster reefs), or allogenic, where organisms transform the physical environment using living or non-living materials (e.g., dam creation by beavers; Jones et al. 2010). The **primary objective** in selecting this species as a surrogate is to better enable and evaluate the species' impact at restoring fundamental natural disturbance processes into valley wetlands. The beaver is widely acknowledged in the scientific literature as a classic surrogate species because its activities in a variety of aquatic environments influence a wide spectrum of other species across many taxa, including aquatic plants and invertebrates, fish, birds, herpetofauna, bats, and other mammals (Boogert et al. 2006, Stevens et al. 2007, Karraker and Gibbs 2009, Caro 2010, Barua 2011, Ciechanowski et al. 2011).

Beavers build dams to create deep water for protection from predators, for access to their food supply and to provide underwater entrances to their den. They enhance habitat for many other fish and wildlife species through these tree-felling and dam-building activities, making beaver presence integral to the recovery of listed fish such as coho salmon (Pollock et al. 2004, Stout et al. 2012) and steelhead (Pollock et al. 2012). These activities create openings and ponds that provide fish habitat, trap

sediments, provide refugia for aquatic species during droughts, and kill trees that then become snags for wildlife. Beaver also mitigate the impacts of climate change, helping conserve and attenuate water flow during periods of drought and enhancing wetland carbon storage (Pollock et al. 2003, Westbrook et al. 2006, Hood and Bayley 2008). Beaver ponds also provide and enhance important areas for people to fish, hunt and view wildlife and can serve as important outdoor laboratories for environmental education.

Figure 4. American beaver, an iconic surrogate species: The beaver is Oregon's State animal, featuring prominently on the State's flag. In 1910 Oregon State University replaced their "Jimmie the Coyote" mascot with a beaver. Native Oregonian and artist, Hugh Hayes, was well known for his "Keep Oregon Green" posters, which featured the beaver.

The beaver is also an **iconic** surrogate species, perhaps the most iconic species in Oregon. Oregon's early economy was built on the trade of beaver pelts. During the 1800s, demand for pelts was so high that fur trappers virtually eliminated the species from many landscapes through unregulated trapping. However, with proper management, beaver have become re-established in many areas throughout their historic range. In 1969, the Oregon Legislature recognized the American beaver by designating it as Oregon's official State animal. The species is depicted on the Oregon State flag, it is the mascot of Oregon State University, and it has long been used to communicate educational conservation messages (Figure 4). Oregon is often referred to as "the Beaver State," and using the beaver as a surrogate species provides tremendous educational opportunities for conservation of fish and wildlife in a variety of urban and rural environments.

It must also be recognized that managing for and with beaver presents a special challenge. On the plus side, managing for beavers in aquatic systems is a highly efficient strategy for aquatic restoration (Boogert et al. 2006, Pollock et al. 2012). They eat the leaves, inner bark, and twigs of aspen (*Populus* sp.), alder (*Alnus* sp.), cottonwood (*Populus* sp.), willow (*Salix* sp.), and other deciduous trees, and they can benefit from a variety of restoration actions such as planting native food plants (e.g., alder, willow, maple (*Acer* sp.), and aspen) along streams, and restoration of riparian areas through fencing and restorative hydrology. Allowing for and encouraging beaver recolonization in appropriate areas is widely viewed as a cost-effective wetland habitat restoration strategy, especially when compared to the cost and challenge of other restoration alternatives that usually involve expensive human engineered solutions (Burchsted et al. 2010).

Although beavers contribute significantly to watershed health, they can also cause economic conflicts by blocking culverts, flooding roads, and cutting down valuable trees. On private lands where beavers are causing damage, landowners can work with ODFW to address the problems while allowing beavers to remain at the site or be relocated to a more suitable area. State, local, and Federal agencies have developed practical strategies and methods for Oregon land managers to enhance beaver populations where their activities can improve fish and wildlife habitat, and to resolve economic or other conflicts where they occur (Needham and Morzillo 2011).

© Melissa Carr

Bradshaw's lomatium: (*Lomatium bradshawii*), or Bradshaw's desert-parsley, is an ***umbrella*** species for other wet prairie plants in the Valley (e.g., Western buttercup [*Ranunculus occidentalis*], Common camas [*Camassia quamash*], and Oregon sunshine [*Eriophyllum lanatum*]). The **primary objective** in selecting this species as a surrogate is to evaluate the success of efforts to conserve it and other species occurring in wet prairie habitats.

This plant was federally listed as endangered without critical habitat in 1988 (U.S. Fish and Wildlife Service 1988). A recovery plan for this species was published in 1993 (U.S. Fish and Wildlife Service 1993). Information for this species, including population and recovery goals, was updated in a 2010 recovery plan that was published for multiple prairie species (U.S. Fish and Wildlife Service 2010). Bradshaw's lomatium normally occurs on seasonally saturated or flooded prairies, adjacent to creeks and small rivers, in alluvial (deposited by water) soils. This plant reproduces entirely from seed, and is pollinated by a variety of insects including beetles, ants, and some small native bees. Most of its habitat has been converted for agricultural, industrial, and residential use. In addition, water diversions and flood control structures have changed historic flooding patterns, which may be critical to seedling establishment. Reductions in natural flooding and fire cycles have also allowed the invasion of trees and shrubs, which will eventually result in the conversion of wet prairies to woodlands.

The Service and our partners are implementing many actions that benefit Bradshaw's lomatium. Some include the development of city and county management plans, species surveys, population augmentation and introduction efforts, and habitat restoration. There is a Willamette Valley Prairie Plant Working Group that helps the Service set recovery priorities for the species and provides a mechanism to share information and resources that benefit the species. Some high priority actions for this species that are not yet implemented or need further development include creating a wet prairie calculator to rapidly assess habitat quality, protecting key populations through conservation easements and management plans, improving habitat and augmenting populations that are close to achieving recovery goals, and obtaining resources for ongoing and post-treatment monitoring, analysis, and adaptive management.

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Willamette Valley Surrogate Species Pilot Wetlands Case Study: Using Beaver Deceivers at The Wetland Conservancy's Minthorn Springs Preserve

Minthorn Springs Preserve is a 6.5 ac (2.6 ha) wetland surrounded by industrial, commercial and residential development in Milwaukie, Oregon. The preserve is co-managed with the City of Milwaukie, who purchased an additional parcel to the wetland. Over the past fifteen years, the wetland has been restored from a degraded blackberry (*Rubus* sp.) and reed canarygrass (*Phalaris arundinacea*) infested property to a thriving, healthy wetland.

© TWC

The wetland provides physical functions such as nutrient cycling, thermal regulation, and flood attenuation. It also attracts a variety of wildlife, including beavers. Beavers enhance habitat for many other fish and wildlife species through tree-felling and dam-building activities, making their presence integral to a healthy wetland system. Beavers were eliminated from much of their historic range during the 1800's, but today their population is rebounding. As they return to long-abandoned watersheds, beaver conflicts with humans have increased. Although beavers are highly beneficial, beaver activity can result in flooding of adjacent landowner's property, felling of trees, and clogging culverts and other pipes.

© Kaegan Scully-Englemeyer

To help keep beavers on the landscape, The Wetlands Conservancy (TWC) and their partner, MidCoast Watersheds Council (MCWC), educate people about the benefits of beavers, particularly their role as "ecosystem engineers." The MCWC also installs devices, such as beaver deceivers, that can help mitigate for conflicts, so that people and beavers can co-exist. A beaver deceiver is a fence that is installed around the upstream end of a beaver baffle to reduce the maintenance associated with the beaver baffles. Beaver baffles help prevent dams in culverts. By installing a fence around the upstream end of the baffle, the beaver will not be able to plug the pipe with debris or sediment.

A beaver deceiver was recently installed at the Minthorn Springs Preserve. The device is regulating the water level to a point that prevents flooding while allowing water to remain in the wetland system on the site. Minthorn Springs Preserve, in addition to TWC's other Portland Metro Area urban preserves, provides a great opportunity to educate the public about the functions that wetlands play in the landscape and the role that beaver and other wildlife species in creating and maintaining healthy wetlands.

The Wetlands Conservancy

Riparian

© Dolan Halbrook

Riparian habitats are those adjacent to rivers and streams or occurring on nearby floodplains and terraces. These habitats are varied and each has a characteristic plant assemblage, which shares the ability to tolerate waterlogged roots for a period of time. Riparian habitats vary from sparsely vegetated areas to cottonwood gallery forests. Riparian areas serve a variety of ecological functions, providing diverse and abundant food sources for wildlife, shade that helps regulate water temperature, carbon storage, and fallen woody debris that create cover for fish and helps form pools and trap gravel that is used as spawning habitat. Riparian vegetation also traps sediment and nutrients, filters sediment and pollutants, and stabilizes stream banks (Mitsch and Gosselink 1993, Horne and Goldman 1994, Watershed Network Professionals 1999). In the Pacific Northwest, riparian areas support some of the highest levels of biodiversity and provide important movement corridors for both aquatic and terrestrial species. In the Willamette Valley, riparian forests have significantly declined with increasing development. Many streams now have only a thin strip of riparian vegetation, and some have none. Despite increasing emphasis on protection of riparian habitats and the formal establishment of the Willamette River Greenway, riparian habitats continue to decline (ODFW 2006).

Surrogate Species in Riparian Habitats

© Thayne Tuason

Black cottonwood: (*Populus balsamifera* ssp. *trichocarpa*) gallery forests are often referred to as ***keystone*** species or habitat because they have a large impact on the ecosystem relative to their abundance on the landscape. The **primary objective** in selecting black cottonwood trees as a surrogate is to better enable cottonwood forest conservation and to monitor and evaluate the success of these cottonwood conservation efforts.

Breeding and migratory bird densities in these cottonwood forests are generally the highest of all habitat types in North America. Mature stands of cottonwood trees provide essential nesting habitat for larger birds, such as bald eagles (*Haliaeetus leucocephalus)*, great-horned owls (*Bubo virginianus*), and great-blue herons (*Ardea herodias*; ODFW 2006). Cottonwood galleries also provide habitats for northern red-legged frogs (*Rana aurora aurora*), a variety of mammals, and other wildlife. Intact riparian areas serve as corridors for many wildlife species. These floodplain areas function as natural floodwater storage areas during high water events, while contributing improved water quality with shade and filtration. In addition, riparian zones provide

woody debris that increases structural diversity to fish-bearing streams (U.S. Fish and Wildlife Service 2011).

Riparian habitats are being restored through cooperative efforts such as The Oregon Plan for Salmon and the Willamette Restoration Initiative. Initial efforts of wood placement, invasive non-native plant control, and riparian vegetation planting have begun to show positive benefits. One of the objectives identified in the Willamette Valley National Wildlife Refuges CCP (U.S. Fish and Wildlife Service 2011) is to protect and maintain mid-late successional black cottonwood-dominated riparian forests. This includes forests on William L. Finley (including Snag Boat Bend Unit) and Ankeny NWRs that have diverse assemblage of native riparian-dependent species including migratory landbirds (e.g., yellow warbler (*Setophaga petechia*)) and native amphibians (e.g., northern red-legged frogs). Management actions include controlling invasive species with integrated pest management including herbicide or other methods where practical and follow-up plantings of native understory species when necessary.

© John Battaso / USFWS

Northern red-legged frog: is a ***management indicator*** species for riparian habitats. The **primary objective** in selecting this species as a surrogate is to use them as a riparian habitat education tool in urban environments.

Northern red-legged frogs use ponds and wetlands with shallow areas and emergent plants, as well as adjacent forested wetland habitats (ODFW 2006). During the non-breeding season, adult frogs spend most of their time on land in woodlands along streams, in moist sedge or brush, along shaded pond edges or under logs and other forest debris. Damp weather permits them to venture away from their primary water source into areas that would normally be too dry. They are inactive if temperatures are too cold or weather is too hot and dry (Lawrence et al. 2005). Limiting factors for this species include loss of egg laying habitat and predation and competition by invasive fish and bullfrogs (ODFW 2006).

Willamette Valley Surrogate Species Pilot Riparian Case Study:

Tracking Amphibian Populations in Urban Areas

Metro initiated several floodplain restoration projects in the region since the open spaces, parks and streams bond measure was passed in 1995. They are tracking pond-breeding amphibian populations to help gauge the effectiveness of these projects.

Starting in February, volunteers search for egg masses to collect information about the distribution and abundance of native pond-breeding amphibians such as the state sensitive northern red-legged frog. The data collected not only helps Metro assess the effectiveness of current restoration work, but also guides management actions and helps to raise grant funds for ongoing restoration work. Volunteers have tracked red-legged frogs as they have expanded throughout nearly 100 ac (40.5 ha) of newly restored seasonal floodplain wetlands at Metro's Multnomah Channel Natural Area. In 2004 volunteers documented more than 100 new red-legged frog masses at its newly restored Gotter Prairie Natural Area. In 2006, volunteers tracked expansions of red-legged frog breeding activity in the Coffee Lake Bottoms Natural Area.

Metro

Aquatic

© Taylor Goforthn/ USFWS

Freshwater aquatic habitats include rivers, streams, ponds, lakes and reservoirs. High quality freshwater systems provide essential habitat to many at-risk species, including important spawning and rearing habitat for salmonids and lamprey, breeding habitat for amphibians, and habitat for freshwater mussels and other invertebrates. In general, the limiting factors in aquatic systems include water quantity, water quality, invasive species, channelization, excessive fine sediments, passage barriers, and degraded riparian condition and loss of habitat complexity. Upland habitats have a critical role in watershed health because they provide shade and filter runoff and precipitation. In the Willamette Valley, many river features (e.g., off-channel aquatic habitat, gravel bars, deep channel pools) have disappeared as land uses have changed over time. Roads, dams, culverts, irrigation diversions, and other barriers have impacted water flow and hydrology, as well as fish and wildlife species. Channelization and development have restricted the natural ability of streams and riparian habitats to meander over time, limiting the quality and availability of these habitats, as well as affecting floodplain function. Subsurface water has become less readily available because of increased impervious surfaces, and large, cool freshwater pools associated with streams are also in decline. Water temperature is often too warm for native aquatic life because of reductions in stream flow, thermal pollution, channel morphology changes, and reduced riparian cover. Urban, agricultural, and forest practices have impacted water quality by contributing point (single localized identifiable source) and nonpoint (diffuse source; e.g., runoff) sources of pollution into aquatic systems. At high enough levels, both point and nonpoint source pollution can cause significant lethal or sub-lethal effects in native fish and wildlife (ODFW 2006).

Surrogate Species in Aquatic Habitats

© Jeremy Monroe / FI

Pacific lamprey: (*Entosphenus tridentatus*) is found throughout the Willamette River Basin and is a ***management indicator*** species. The **primary objective** in selecting Pacific lamprey as a surrogate is to develop insight into habitat conditions for this and other species utilizing freshwater aquatic environments in the Willamette River Valley. Lamprey is also an ***iconic*** species for Native American Tribes living in the Pacific Northwest, including the Valley.

Adult lampreys are parasitic in the ocean for 1-2 years, and then enter the Willamette River in early spring. Some spawn immediately and others overwinter in boulder and bedrock crevices and spawn the following year. Lampreys spawn in similar gravel habitats as salmon and, like salmon, die after spawning (Figure 5). Their role in water quality and food web dynamics for both aquatic and terrestrial species is crucial to ecosystem function. Adults provide oceanic nutrients to stream and riparian systems, larvae provide food for aquatic and terrestrial species and cycle stream nutrients, and juveniles provide food for birds

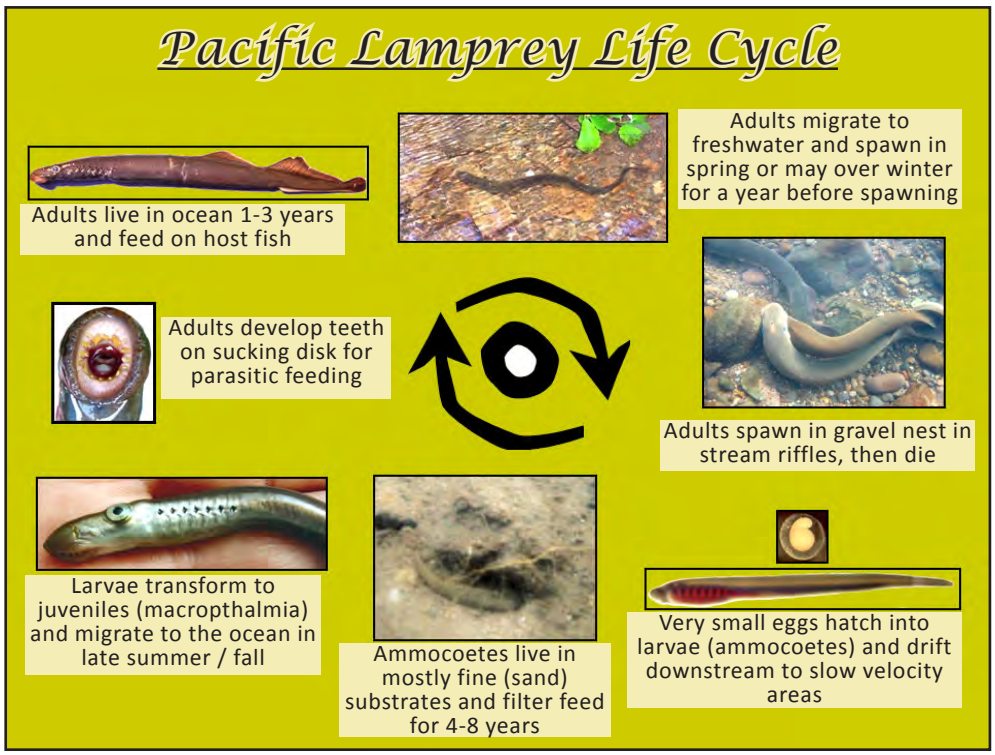

Figure 5. Diagram of Pacific lamprey life cycle (adapted from Streif 2009).

and fish and may serve as a predator buffer on salmonids. Lampreys spend most of their life, about 10.5 years, in a variety of freshwater habitats. Conservation actions aimed at lampreys are expected to benefit a variety of aquatic species including Chinook salmon (*Oncorhynchus tshawytscha*) and coastal cutthroat trout (*Oncorhynchus clarki clarki*).

The Willamette River is the stronghold for lampreys within the Columbia River system and is an essential area for their conservation. Lampreys are an important cultural, medicinal, and food source for many of the Tribes such as the Warm Springs, Umatilla, Grande Ronde, Cowlitz, Chinook, and Siletz Tribes. Tribes have come to the Willamette Falls for thousands of years to gather lampreys during their upstream migration, which is why the Tribes are the primary advocate of lamprey recovery and conservation.


© Bianca Streif

Second Lamprey Summit

After two Lamprey Summits hosted by the Tribes, the Pacific Lamprey Conservation Initiative was developed as a partnership led by the Service to facilitate communication and coordination relative to the conservation of Pacific lampreys throughout their range. The goal of the initiative is to develop a Pacific Lamprey Conservation Plan that will lead to restored Pacific lamprey populations and improvement of their habitat. A status assessment was published in 2010. At the third Lamprey Summit in 2012, a conservation agreement was signed by over 11 Tribes, six States, 14 Federal agencies, and many others with a commitment to increase lamprey awareness, fill gaps in restoration actions, and efficiently use limited resources to swiftly implement Pacific lamprey conservation actions.

The Service, in partnership with ODFW, has begun to develop action plans to address priority actions in the Willamette River Valley. In addition, numerous lamprey projects are ongoing with ODFW, the Warm Springs and Grande Ronde Tribes, several watershed councils, Oregon State University, U.S. Geological

Survey, the City of Portland and other groups. Primary threats to lampreys in the Willamette River Basin include:

1. Blocked passage – dams, culverts, and diversion structures.
2. Dewatering and flow management – reservoir and downstream water level fluctuations and agricultural and municipal water withdrawals.
3. Stream and floodplain degradation – channelization and loss of habitat from agricultural and urban land use.
4. Degraded water quality – elevated temperatures, chemical contaminants in the water and substrates from agricultural and urban land use.
5. Predation from non-native fish species.

Western pearlshell: (*Margaritifera falcata*) is a ***sentinel*** species that is found in permanent creeks, rivers, sloughs, and streams. The **primary objective** for this surrogate species is to evaluate specific water quality criteria and how various water quality conditions might affect mussels and other species with similar requirements. It is also an excellent indicator of channel stability since they reside on substrate for up to 100 years (Hastie and Toy 2008) and are essentially the old-growth forests of our aquatic ecosystems. In addition, their dependency on native fish species to complete their life cycle integrates them into the aquatic ecosystem.

The western pearlshell prefers areas of clear, cold water (Frest and Johannes 1995) and concentrate in areas of low velocity flow and stable substrate conditions, such as eddies or pools (Howard and Cuffey 2003) and areas with boulders that likely shelter mussel beds (Vannote and Minshall 1982). Western pearlshell mussels appear to be intolerant of fine sediments in the mussel beds (Vannote and Minshall 1982). Freshwater mussels, including the western pearlshell, have a complex life cycle (Figure 6). Males release sperm into the water, which is then inhaled by females for fertilization. Females develop the fertilized embryos into larvae called glochidia. These glochidia are often in groups which clamp onto fins or gill filaments of fish, which they parasitize for several weeks to months and then drop into the substrate where they attach and grow for decades. The fish serve as a dispersal mechanism for the freshwater mussels. The western pearlshell glochidia depend on native salmonids as a host. The chances of an individual glochidia finding a host, attaching, landing in suitable habitat and reaching adulthood are incredibly slim (Nedau et al. 2009).

Native freshwater mussels have immense cultural and ecological significance. Historically, freshwater mussels were important sources of food, tools, and other implements for Native Americans Tribes and have been harvested for at least 10,000 years in the interior Columbia Basin (The Xerces Society 2013). These filter-feeders are important to food webs, water quality, nutrient cycling, and habitat quality in freshwater ecosystems (Howard and Cuffery 2006, Vaughn et al. 2008). Adult freshwater mussels are excellent indicators of ecosystem health due to their limited mobility and long lifespan. Thus, they are easy to monitor and their populations can reflect cumulative effects of environmental conditions and extreme events over time. Freshwater mussels are sensitive to changes in water quality, habitat, and fish communities. The factors affecting the western pearlshell, and other western freshwater mussels, include water availability, dams, introduced species, loss of host fish species, and the chronic effects of urbanization, agriculture and logging on aquatic habitat quality (Nedau et al. 2009). In North America freshwater mussels are in decline; nearly three-quarters of all 297 native species are imperiled and

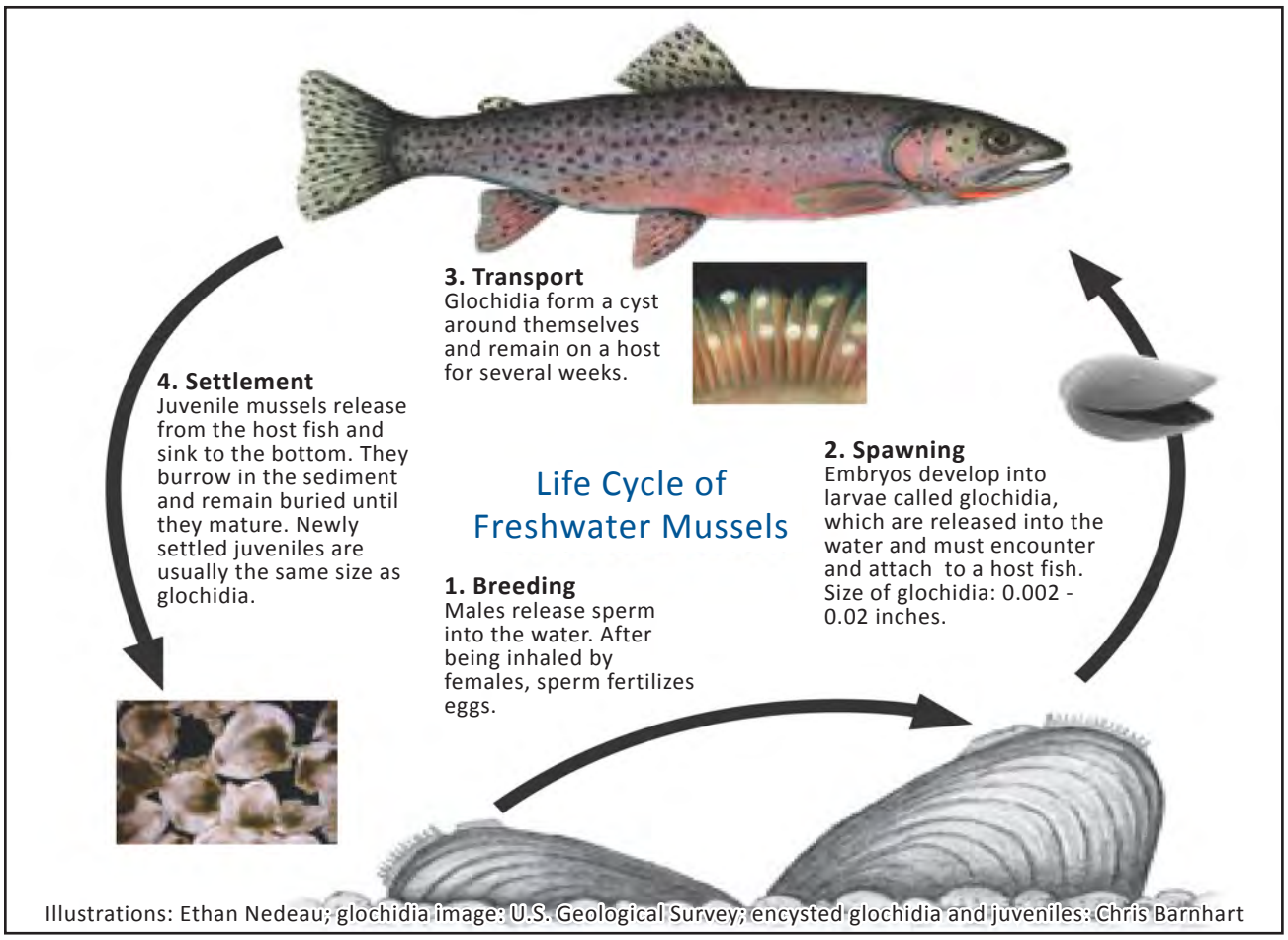

Figure 6. Diagram of freshwater mussel life cycle (Nedeau et al. 2009).

35 are thought to have gone extinct in the last century (Master et al. 2000). There is need for research on freshwater mussel biology, distribution, status, and threats for effective conservation of western mussels. Recently, conservation organizations have conducted surveys to collect baseline data on western mussels in the Willamette Valley and The Xerces Society has completed status reviews for several species.

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Willamette Valley Surrogate Species Pilot Aquatic Case Study: Pacific Lamprey Conservation

The Pacific lamprey is an anadromous fish that requires access from the ocean to suitable rivers and streams to spawn in similar habitats as salmon. Various physical passage barriers, including low elevation dams and perched culverts, significantly limit distribution and abundance of lamprey. Barriers impede adult upstream migration and downstream movement of larvae and outmigrating juveniles. Pacific lampreys are weaker swimmers than salmon. Thus, many projects that benefit salmon are not suitable for lampreys.

Pacific lampreys are unique in their ability to climb near vertical surfaces to move upstream over natural waterfalls. They use their oral discs to attach to suitable substrates and then release and use their body to "burst" themselves up a waterfall; this is known as burst-and-attach behavior. Lamprey specific structures (LPS; or lamprey ramps) allow lamprey to use their unique burst-and-attach behavior to pass over barriers more effectively. Many passage projects have been implemented in the Columbia and Willamette River Basins to remove impediments or provide alternative passage at dams and in ladders designed for salmon.

The Service leads the regional, multi-state Lamprey Conservation Initiative with support from the Tribes, as well as Federal, State, county, and private partners. This effort supports the implementation of new projects, and builds on prior efforts to improve lamprey passage based on research indicating an overall passage success. As an example, in the early 2000s, the Service partnered with National Marine Fisheries Service (NMFS), Army Corp of Engineers (COE), and Columbia River Tribes to fund and install lamprey ramps at several locations on the COE's Bonneville Dam on the Columbia River. Funding also was provided to the Confederated Tribes of the Umatilla Reservation to work with NMFS and the West Extension Irrigation District to install a LPS on the Three Mile Falls Diversion Dam and other low passage barriers further upstream. Similarly, the Service worked with Portland General Electric at the Willamette Falls Hydroelectric Project to reduce impediments to lamprey within the existing salmon ladder, and provide lamprey ramps in impassable areas where lamprey were known to congregate below the falls. Installation of the ramps at all of these locations has proven to be successful in providing instant passage to lamprey in these otherwise blocked areas.

Other projects that the Initiative has been involved with include the complete removal of old, no longer used dams which benefit many species. As an example, in 2011, the Service worked with Oregon Parks and Recreation Department, the Calapooia Watershed Council, Tribes, and other partners to remove Sodom Dam on the Calapooia River. The removal of Sodom Dam and subsequent restoration of this site has improved passage for Pacific lamprey, spring Chinook salmon, and steelhead and, improved the river's hydrological processes and habitats that support these and other aquatic and terrestrial species.

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Pacific lamprey passing over ramp at Willamette Falls.

Biological Objectives and Priority Actions For Surrogate Species

We considered the following when setting biological objective(s) for surrogates:

- Use existing biological objective(s) from partners' efforts for surrogates and other species when available and still considered appropriate.
- For State trust species (those that are not federally listed, migratory birds, and some marine mammals and interjurisdictional fish) biological objectives identical to the state biological objective or combined state objectives were selected when available.
    - If none were available, then we developed biological objectives with ODFW and the Team.
- For Federal trust species, if no biological objectives were available, then objectives were developed with ODFW and the Team.
- Considered knowledge about known or assumed limiting factors for both the surrogate species and Federal/State species requiring special attention, to include both the stressor(s) and proximate sources of stress.
- Any existing or emerging conservation actions or strategies that alleviate crucial limiting factors, including any existing SMART (Specific, Measurable, Achievable, Relevant, Time sensitive) objectives.

Biological objectives for each of the surrogate species are described in Table 2. This table also lists priority actions, as well as some of the partners implementing the actions that support the biological objectives.

Summary

The SHC approach in the Willamette Valley is centered on working closely with partners to maximize the use of limited resources and to focus these resources on conservation efforts that have the greatest potential to conserve habitat and species in the Willamette Valley. Our approach builds on the decades of work and the multiple strategic planning efforts conducted by Willamette Valley partners, as previously described in our meta-review approach. We selected an assortment of surrogate species types for strategy habitats in the Valley, including umbrella, indicator, iconic, engineering, keystone, and sentinel species. The Team also identified biological objectives and conservation and monitoring actions for each surrogate species.

Strategic habitat conservation in the valley will be a continuous iterative process of biological planning, conservation design, conservation delivery, and outcome-based monitoring. Biological planning and conservation design may be adjusted with newly available scientific information about species, habitats, and conservation tools. Conservation delivery will vary with resource and partnership availability. Outcomes-based monitoring of the surrogate species will help inform future management decisions. We will continue to work with our partners to implement and refine, as appropriate, the surrogate species approach for the Willamette Valley.

Table 2. Biological objectives and supporting conservation and monitoring actions for the Willamette Valley surrogate species.

Habitat	Species	Biological Objectives	Priority Conservation and Monitoring Actions	Partners [1]	Status
Oak Woodland	Oregon White Oak	Reduce the rate of Oregon white oak woodland loss in the Willamette Valley, with the long-term goal of increased recruitment.	1. Protect/manage oak woodland habitat.	ODFW, Service, TNC, WP, DOW, land trusts, local park providers, local governments	Ongoing
			2. Control invasives (e.g., conifers) in priority oak woodlands.	ODFW, Service, TNC, land trusts, local park providers, local governments	Ongoing
			3. Restore or mimic natural disturbance processes.	ODFW, Service, TNC, land trusts, local park providers, local governments	Ongoing
	Slender-Billed White-Breasted Nuthatch	Stabilize the population trends of this species on Breeding Bird Survey (BBS) routes in the Willamette Valley.	1. Protect/manage oak woodland habitat.	ODFW, Service, TNC, WP, DOW, Metro, land trusts, local governments	Ongoing
			2. Maintain large oaks > 22 inches dbh.	ODFW, Service, TNC, WP, DOW, Metro, land trusts	Ongoing
			3. Develop a nest box program.	TBD	Not started
			4. Develop or adopt and implement a monitoring strategy for this species.	TBD	Not started

[1] The list of partners is growing and ongoing.

Habitat	Species	Biological Objectives	Priority Conservation and Monitoring Actions	Partners [1]	Status
Grasslands	Fender's Blue Butterfly (FBB)	Meet the downlisting goal of two permanently protected networks in each of the three recovery zones, meeting criteria outlined on pp. IV-29 to IV-31 of the FBB Recovery Plan (U.S. Fish and Wildlife Service 2010).	1. Develop a strategic habitat conservation approach for FBB in Lane County (e.g., HCP).	ODA, Service, and other partners	Not started
			2. Achieve Salmon-Safe+ certification for upland prairie with FBB Safe Harbor Agreement Assurances.	Service, WP, Salmon-Safe	Ongoing
			3. Improve habitat quality at protected FBB locations; increase native plant diversity, especially nectar species.	ODFW, ODA, Service, TNC, NRCS, WP, Institute of Applied Ecology (IAE), WSU, Oregon State University (OSU), BLM, Greenbelt Land Trust, local governments, watershed councils, SWCDs, COE, BOR, ODOT, OWEB	Ongoing
	Western Meadowlark	Stabilize the population trends of western meadowlarks on BBS routes in the Willamette Valley.	1. Develop and implement a monitoring strategy for the species that is tied with FBB monitoring.	Service and other partners	Not started
			2. Evaluate the utility of western meadowlark as a surrogate species for grassland habitats.	TBD	Not started
			3. Preserve grassland habitat, especially areas over 100 acres (40.5 ha) and improve habitat connectivity.	ODFW, ODA, Service, land trusts, OWEB	Ongoing

[1] The list of partners is growing and ongoing.

Habitat	Species	Biological Objectives	Priority Conservation and Monitoring Actions	Partners [1]	Status
Wetlands	American Beaver	Manage beaver where currently present and, where absent, evaluate areas where beaver presence would help achieve habitat goals.	1. Protect priority wetlands.	TWC, TNC, ODFW, Service, DOW, land trusts, local park providers, local governments, NRCS	Ongoing
			2. Further understanding / education about the role of beavers in wetlands.	TWC, ODFW, Service, DOW	Ongoing
			3. Incorporate beavers into site management, using them to achieve wetland improvement.	TWC, TNC, land trusts	Ongoing
			4. Reduce beaver conflicts in the Valley and encourage presence of beavers where lacking.	TWC, ODFW, Service	Ongoing
	Bradshaw's Lomatium	Meet the downlisting goal of 12 populations / zones, meeting criteria outlined on pp. IV-31 to IV-33 of the recovery plan (U.S. Fish and Wildlife Service 2010).	1. Develop a wet prairie "calculator" to estimate wet prairie condition and extent.	WP, Service	Not started
			2. Focus conservation on recovery zones east of the Willamette River, especially Salem East and Eugene East.	ODA, Service, NRCS, and other partners	Ongoing
			3. Improve habitat and augment populations for Bradshaw's lomatium and associated species, focusing first on Bradshaw's lomatium recovery zones that do not currently meet recovery goals.	ODA, Service, IAE, OWEB	Ongoing

[1] The list of partners is growing and ongoing.

Habitat	Species	Biological Objectives	Priority Conservation and Monitoring Actions	Partners [1]	Status
Riparian	Black Cottonwood	Reduce the rate of black cottonwood forest loss in the Willamette Valley, with the long-term goal of increased recruitment.	1. Protect and manage black cottonwood forests.	Oregon Parks and Recreation Department, land trusts, local park providers	Ongoing
			2. Increase cottonwood recruitment.	TBD	TBD
			3. Maintain all cottonwood trees greater than 20 in (50.8 cm) diameter regardless of landscape context.	TBD	TBD
	Northern Red-Legged Frog	Maintain wetland habitat with emergent plants, and maintain adjacent forested habitats.	1. Support and build on Metro's monitoring efforts.	Metro, other local park providers	Ongoing
			2. Identify and protect / enhance overwintering habitat (ODFW 2006).	TBD	TBD
			3. Use northern red-legged frog as a riparian habitat education tool in urban environments.	Metro, Service, watershed councils	Ongoing
			4. Control bullfrogs and invasive fish at key sites.	TBD	TBD

[1] The list of partners is growing and ongoing.

Habitat	Species	Biological Objectives	Priority Conservation and Monitoring Actions	Partners [1]	Status
Aquatic	Pacific Lamprey	Increase adult spawning abundance in the Willamette River and tributaries.	1. Improve or provide passage at dams, diversions, and culverts.	COE, ODOT, Service, ODFW, BOR, Tribes, watershed councils	Ongoing
			2. Avoid dewatering streams and develop methods to further minimize the effects of dewatering when it must occur.	Service	Ongoing – guidelines started
			3. Map extent of their distribution.	Service – Columbia River Fisheries Office	Ongoing – started 2014
			4. Improve water quality and monitor effects of contaminated substrate on larvae.	City of Portland, Tribes, COE	Ongoing
			5. Increase awareness of Pacific lamprey ecological and cultural benefits and special needs.	Service, OSU, Tribes	Ongoing
	Western Pearlshell	Protect and enhance habitat of freshwater mussels.	1. Avoid dewatering streams and continue to develop methods to relocate mussel colonies when necessary.	Interagency Freshwater Mussel Working Group	Methods – Ongoing; De-watering - Not started
			2. Reduce fine sediment and instream trampling.	National Marine Fisheries Service (NMFS), Service, ODFW, Department of Environmental Quality	TBD
			3. Improve fish passage for salmonids (host species).	NMFS, Service, ODFW, ODOT, watershed councils, land trusts	Ongoing

[1] The list of partners is growing and ongoing.

References

Altman, B. 1999. Status and conservation of state sensitive grassland bird species in the Willamette Valley. Unpublished report, submitted to Oregon Department of Fish and Wildlife.

Altman, B. 2003. Western meadowlark (*Sturnella neglecta)*. Pages 580-582 in: D.B. Marshall, M.G. Hunter, and A.L. Contreras (eds). Birds of Oregon: A General Reference. Oregon State University Press, Corvallis, Oregon. 752 pp.

Atlman, B. and J.L. Stephens. 2012. Land managers guide to bird habitat and populations in oak ecosystems of the Pacific Northwest. American Bird Conservancy and Klamath Bird Observatory. 82 pp.

Andelman, S.J. and W.F. Fagan. 2000. Umbrellas and flagships: efficient conservation surrogates or expensive mistakes? Proceedings of the National Academy of Sciences 97(11): 5954-5959.

Barua, M. 2011. Mobilizing metaphors: the popular use of keystone, flagship, and umbrella species concepts. Biodiversity Conservation 20: 1427-1440.

Boogert, N.J., D.M. Paterson, and K.N. Laland. 2006. The implications of niche construction and ecosystem engineering for conservation biology. BioScience 56(7): 570-578.

Burchsted, D., M. Daniels, R. Thorson, and J. Vokoun. 2010. The river discontinuum: applying beaver modifications to baseline conditions for restoration of forested headwaters. BioScience 60(11): 908-922.

Caro, T. 2010. Conservation by proxy: indicator, umbrella, keystone, flagship, and other surrogate species. Island Press, Washington DC. 374 pp.

Caro, T.M. and G. O'Doherty. 1999. On the use of surrogate species in conservation biology. Conservation Biology 13(4): 805-814.

Chase, M.K., W.B. Kristan III, A.J. Lynam, M.V. Price, and J.T. Rotenberry. 2000. Single species as indicators of species richness and composition in California coastal sage scrub birds and small mammals. Conservation Biology 14(2): 474-487.

Che-Castaldo, J.P. and M.C. Neel. 2012. Testing surrogacy assumptions: can threatened and endangered plants be grouped by biological similarity and abundances? PLoS ONE 7(12): e51659.

Ciechanowski, M., W. Kubie, A. Rynkiewicz, and A. Zwolicki. 2011. Reintroduction of beavers *Castor fiber* may improve habitat quality for vespertilionid bats foraging in small river valleys. European Journal of Wildlife Research 57: 737-747.

Cole, D. 1977. Ecosystem dynamics in the coniferous forest of the Willamette Valley, Oregon, U.S.A. Journal of Biogeography 4(2): 181-192.

DeMars, C.A., D.K. Rosenberg, and J.B. Fontaine. 2010. Multi-scale factors affecting bird use of isolated remnant oak trees in agro-ecosystems. Biological Conservation 143: 1485-1492.

Favreau, J.M., C.A. Drew, G.R. Hess, M.J. Rubino, F.H. Koch, and K.A. Eschelbach. 2006. Recommendations for assessing the effectiveness of surrogate species approaches. Biodiversity and Conservation 15: 3949-3969.

Fleishman, E., R.B. Blair, and D.D. Murphy. 2001. Empirical validation of a method for umbrella species selection. Ecological Applications 11(5): 1489-1501.

Floberg, J., M. Goering, G. Wilhere, C. MacDonald, C. Chappell, C. Rumsey, Z. Ferdana, A. Holt, P. Skidmore, T. Horsman, E. Alverson, C. Tanner, M. Bryer, P. Iachetti, A. Harcombe, B. McDonald, T. Cook, M. Summers, and D. Rolph. 2004. Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment, Volume One: Report. Prepared by The Nature Conservancy with support from the Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon State Natural Heritage Information Center, and the British Columbia Conservation Data Centre.

Frest, T.J. and E.J. Johannes. 1995. Interior Columbia Basin mollusk species of special concern. Final report to the Interior Columbia Basin Ecosystem Management Project, Walla Walla, Washington. Contract #43-0E00-4-9112. 274 pp + appendices.

Gumtow-Farrior, D. L. 1991. Cavity resources in Oregon white oak and Douglas-fir stands in the mid-Willamette Valley, Oregon. M.S. thesis, Oregon State University, Corvallis, Oregon. 89 pp.

Habeck, J.R. 1961. The Original Vegetation of the Mid-Willamette Valley, Oregon. Northwest Science 35(2): 65-77.

Hagar, J. C. 2003. White-breasted nuthatch (*Sitta carolinensis*). Pages 449-451 in D.B. Marshall, M.G. Hunter, and A.L. Contreras. Birds of Oregon: A General Reference. Oregon State University Press, Corvallis, Oregon. 752 pp.

Hagar, J. 2012. Summary of bird-survey and banding results at W.L. Finley National Wildlife Refuge, 1998–2008: U.S. Geological Survey Open-File Report 2012-1223. 12 pp.

Hastie, L.C. and K.A. Toy. 2008. Changes in density, age structure and age-specific mortality in two western pearlshell (*Mararitifera falcate*) populations in Washington (1995-2006). Aquatic Conservation: Marine and Freshwater Ecosystems 18: 671-678.

Hitt, N.P. and C.A. Frissell. 2004. A case study of surrogate species in aquatic conservation planning. Aquatic Conservation: Marine and Freshwater Ecosystems 14: 625-633.

Hood, G.A. and S.E. Bayley. 2008. Beaver (*Castor Canadensis*) mitigate the effects of climate on the area of open water in boreal wetlands in western Canada. Biological Conservation 141: 556-567.

Horne, Alexander J. and Charles R. Goldman. 1994. Limnology Second Edition. McGraw Hill, Inc.. New York.

Howard, J.K. and K.M. Cuffey. 2003. Freshwater mussels in a California North Coast Range river: occurrence, distribution, and controls. Journal of the North American Benthological Society. 22: 66-77.

Howard, J.K., and K.M. Cuffery. 2006. The functional role of native freshwater mussels in the fluvial benthic environment. Freshwater Biology. 51: 460-474.

Intertwine Alliance. 2012. Regional Conservation Strategy for the Greater Portland-Vancouver Region. A. Sihler, editor. The Intertwine Alliance, Portland, OR. www.theintertwine.org.

Jackson, J. 1979. Tree surfaces as foraging substrates for insectivorous birds in Dickson, J.G., R.N. Conner, R.R. Fleet, J.A. Jackson, and J.C. Kroll (Eds.). The role of insectivorous birds in forest ecosystems. Academic Press, Inc., New York, New York, USA.

Jerrick, N. February 2001. Restoring a river of life: the Willamette restoration strategy overview. Prepared for the Willamette Restoration Initiative, Salem, OR.

Jones, C.G., J.L. Gutierrez, J.E. Byers, J.A. Crooks, J.G. Lambrinos, and T.S. Talley. 2010. A framework for understanding physical ecosystem engineering by organisms. Oikos. 119: 1862-1869.

Karraker, N.E. and J.P. Gibbs. 2009. Amphibian production in forested landscapes in relation to wetland hydroperiod: a case study of vernal pools and beaver ponds. Biological Conservation 142: 2293-2302.

Lawrence, L., C. Jones, W.P. Leonard, and D.H. Olson (Eds.) 2006. Amphibians of the Pacific Northwest. Seattle Audubon Society, Seattle. 227 pp.

Lewandowski, A.S., R.F. Noss, and D.R. Parsons. 2010. The effectiveness of surrogate taxa for the representation of biodiversity. Conservation Biology 24(5): 1367-1377.

Lindenmayer, D.B. and G.E. Likens. 2011. Direct measurement versus surrogate indicator species for evaluating environmental change and biodiversity loss. Ecosystems 14: 47-59.

Master L.L., B.A. Stein, L.S. Kutner, and G.A. Hammerson. 2000. Vanishing assets: Conservation status of U.S. species. Pages 93-118 in: B.A. Stein, L.S. Kutner, and J.S. Adams (eds). Precious heritage: the status of biodiversity in the United States. Oxford University Press.

Mills, L.S., M.E. Soule, and D.F. Doak. 1993. The keystone-species concept in ecology and conservation. BioScience 43(4): 219-224.

Mitsch, W.J. and J.G. Gosselink. 1993. Wetlands, 2nd ed. John Wiley, New York.

Murphy, D.D., P.S. Weiland, and K.W. Cummins. 2011. A critical assessment of the use of surrogate species in conservation planning in the Sacramento-San Joaquin Delta, California (U.S.A.). Conservation Biology 25(5): 873-878.

Myers, A. M., and D. A. Kreager. 2010. Declining and state sensitive bird species breeding in Willamette valley grasslands: status update. Unpublished report prepared for Oregon Department of Fish and Wildlife, Corvallis, and The Oregon Zoo, Portland.

Nedeau, E.J., A.K. Smith, J. Stone, and S. Jepsen. 2009. Freshwater Mussels of the Pacific Northwest. The Xerces Society. 51 pp.

Needham, M.D. and A.T. Morzillo. 2011. Landowner incentives and tolerances for managing beaver impacts in Oregon. Final Report.

Nelson, P., R. White, and R. Molina. 2006. The Pacific Northwest Research Station's Biodiversity Initiative: collaborating for biodiversity management. Gen. Tech. Rep. PNW-GTR-670. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 32 pp.

Niemi, G.J. and M.E. McDonald. 2004. Application of ecological indicators. Annual Review of Ecology, Evolution, and Systematics 35: 89-111.

Oregon Department of Fish and Wildlife. 2006. Oregon's Comprehensive Wildlife Conservation Strategy. Oregon Department of Fish and Wildlife, Salem, Oregon.

Ozaki, K., M., Isono, T. Kawahara, S. Iida, T. Kudo, and K. Fukuyama. 2006. A mechanistic approach to evaluation of umbrella species as conservation surrogates. Conservation Biology 20: 1507–1515.

Pacific Northwest Ecosystem Research Consortium. 2002. Willamette River basin planning atlas: trajectories of environmental and ecological change in Hulse, D., S. Gregory, and J. Baker, eds., Oregon State University Press, Corvallis. Accessed February 25, 2014, at: http://www.fsl.orst.edu/pnwerc/wrb/Atlas_web_compressed/PDFtoc.html

Pollock, M.M., M. Heim, and D. Werner. 2003. Hydrologic and geomorphic effects of beaver dams and their influence on fishes. American Fisheries Society Symposium.

Pollock, M. M., G.R. Pess, and T.J. Beechie. 2004. The importance of beaver ponds to coho salmon production in the Stillaguamish River Basin, Washington, USA. North American Journal of Fisheries Management 24: 749-760.

Pollock, M.M., J. Wheaton, N. Bouwes, C. Jordan, and N. Weber. 2012. Using beaver to reconnect floodplains and restore riparian habitat in an incised stream. Proceedings of the American Water Resources Association; Riparian ecosystems IV: advancing science, economics, and policy 2012 Summer Specialty Conference. Pp. 31-36.

Power, M.E., D. Tilman, J.A. Estes, B.A. Menge, W.J Bond, L.S. Mils, G. Daily, J.C. Castilla, J. Lubchenco, and R.T. Paine. 1996. Challenges in the quest for keystones. BioScience 46: 609-620.

Rickleffs, R.E., Z. Naveh, and R.E. Turner. 1984. Conservation of ecological processes. The Environmentalist 4(8): 6-16.

Simberloff, D. 1998. Flagships, umbrellas, and keystones: is single-species management passé in the landscape era? Biological Conservation 83(3): 247-257.

Stevens, C.E., C.A., Paszkowski, and A.L. Foote. 2007. Beaver (*Castor Canadensis*) as a surrogate species for conserving anuran amphibians on boreal streams in Alberta, Canada. Biological Conservation 134: 1-13.

Stout, H.A., P.W. Lawson, D.L. Bottom, T.D. Cooney, M.J. Ford, C.E. Jordan, R.G. Kope, L.M. Kruzic, G.R. Pess, G.H. Reeves, M.D. Scheuerell, T.C. Wainwright, R.S. Waples, E. Ward, L.A. Weitkamp, J.G. Williams, and T.H. Williams. 2012. Scientific conclusions of the status review for Oregon coast coho salmon (*Oncorhynchus kisutch*). U.S. Department of Commerce, NOAA Technical Memo. NMFS-NWFSC-118, 242 pp.

Streif, B. 2009. Considering Pacific lampreys when implementing instream activities. American Fisheries Society Symposium 73: 255-268.

The Nature Conservancy. 2012. Willamette Basin Synthesis Project Map (created 2008, updated 2012).

The Xerces Society. 2013. http://www.xerces.org/western-freshwater-mussels/. Accessed December 30, 2013.

Thilenius, J.F. 1968. The *Quercus Garryana* Forests of the Willamette Valley, Oregon. Ecology 49(6): 1124-1133.

U.S. Fish and Wildlife Service. 1988. Endangered and threatened wildlife and plants: Final endangered status for *Lomatium bradshawii* (Bradshaw's lomatium). Federal Register 53: 38448-38451. September 30, 1988.

U.S. Fish and Wildlife Service. 1993. Bradshaw's lomatium Recovery Plan. Portland, Oregon. 52 pp.

U.S. Fish and Wildlife Service. 2000. Endangered and threatened wildlife and plants: Endangered status of *Erigeron decumbens* var. *decumbens* (Willamette daisy) and Fender's blue butterfly (*Icaricia icarioides fenderi*) and threatened status for *Lupinus sulphureus* ssp. *kincaidii* (Kincaid's lupine). Federal Register 65: 3875-3890. January 25, 2000.

U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants: Designation of critical habitat for the Fender's blue butterfly (*Icaricia icarioides fenderi*), *Lupinus sulphureus* ssp. *kincaidii* (Kincaid's lupine), and *Erigeron decumbens* var. *decumbens* (Willamette daisy); final rule. Federal Register 71: 63862-63977. October 31, 2006.

U.S. Fish and Wildlife. 2008. Strategic Habitat Conservation Handbook: A Guide to Implementing the Technical Elements of Strategic Habitat Conservation (Version 1.0). June 2008. 22 pp.

U.S. Fish and Wildlife Service. 2010. Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington. U.S. Fish and Wildlife Service, Portland, Oregon. xi + 241 pp.

U.S. Fish and Wildlife Service. September 2011. Willamette Valley National Wildlife Refuge Complex Final Comprehensive Conservation Plan and Environmental Assessment.

U.S. Fish and Wildlife Service. September 2013. Tualatin River National Wildlife Refuge Comprehensive Conservation Plan.

U.S. Forest Service. July 2011. Biodiversity Monitoring: Building a Framework for the Northwest (update of March 2006 proposal).

U.S. Geological Survey. 2011. Gap Analysis Program (GAP). National Land Cover, May 2011, Version 2.

Vannote, R.L. and G.W. Minshall. 1982. Fluvial processes and local lithology controlling abundance, structure, and compositions of mussel beds. Proceedings of the National Academy of Sciences 79: 4103-4107.

Vaughn, C.C., S.J. Nichols, and D.E. Spooner. 2008. Community and foodweb ecology of freshwater mussels. Journal of the North American Benthological Society 27: 409-423.

Vesely, D.G. and G. Tucker. 2004. A landowner's guide to restoring and managing Oregon white oak habitats. Pacific Wildlife Research. Corvallis, Oregon.

Washington Department of Fish and Wildlife. 2005. Comprehensive Wildlife Conservation Strategy. 619 pp + appendices.

Watershed Professionals Network. 1999. Oregon Watershed Assessment Manual. June 1999. Prepared for the Governor's Watershed Enhancement Board, Salem, Oregon.

Weins, J.A., G.D. Hayward, R.S. Holthausen, and M.J. Wisdom. 2008. Using Surrogate Species and Groups for Conservation Planning and Management. BioScience 58(3): 241-252.

Westbrook, C.J., D.J. Cooper, and B.W. Baker. 2006. Beaver dams and overbank floods influence groundwater-surface water interactions of a Rocky Mountain riparian area. Water Resources Research 42, W06404, doi:10.1029/2005WR004560.

APPENDIX A. Types of surrogate species (adapted from Caro 2010).

Species Type	Principal Objective	Measures	Assumptions
Indicator Species: *Used to assess the magnitude of anthropogenic disturbance, to monitor population trends in other species, and locate high areas of regional biodiversity (Caro and O'Doherty 1999).*			
Biodiversity Indicator	Identify areas of biological significance	Other species	Distributional data about species within a taxon predict geographic distributions of biodiversity; little success at large scale.
Environmental Indicator Species	Assess extent of disturbance	Environmental change	Used in pollution studies.
Sentinel Species	Assess extent of disturbance	Environmental or change other species	Similar to environmental indicator species.
Ecological-Disturbance Indicator	Assess effects of disturbance on species	Environmental change	By protecting indicator species, other species are protected.
Cross-Taxon – Response Indicator Species	Assess other species' responses to environmental change	Other species	Their presence or population size may be indicative of environmental change and predict the response of other taxa to environmental change.
Management Indicator Species	Assess effects of management on that species and others	The indicator species or other species' populations	Their population changes are believed to indicate the effects of management activities on other species of selected biological communities or on water quality.
Foundation Species "Dominant Species"	Conserve populations	Other species' populations	Group of critical species which define much of the structure of the community. Example: Intertidal mussels displace seaweed/barnacles from rocks but provide habitat for many invertebrates.
Umbrella Species: *Used to delineate the type of habitat or size of area for protection (Caro and O'Doherty 1999).*			
Umbrella Species	Identifying location, size, shape of reserves	Other species' populations, other taxa	Presence of a specific species in a geographic area means other species will be present. Example: group of hummingbirds, butterflies.
Management Umbrella Species	Manage populations	Other species' populations	By maintaining the viability of one species, populations of sympatric species will maintain positive growth rates.
Landscape Species	Identify location, size of reserve and manage it	Other species' and populations	Species using large ecologically diverse areas and often having significant impacts on the structure and function of natural landscapes.

Species Type	Principal Objective	Measures	Assumptions
Flagship Species: *Used to attract public attention (Caro and O'Doherty 1999).*			
Flagship Species	Raise conservation awareness and funds	Habitat, that species	Protection of other species is accomplished through protection of a charismatic species (umbrella effect).
Flagship Umbrella Species	Raise public support / political will for reserves	Habitat	Similar to classic umbrella species.
Iconic Species	Raise awareness and funds	Habitat, that species	Species are famous because of peculiar trait, live in particular habitat, or associated with a country.
Keystone Species: *Species whose impact on community or ecosystem is disproportionately large relative to its abundance (Mills et al. 1993 and Power et al. 1996).*			
Keystone Species	Conserve populations	Other species' or populations	Species whose presence or absence affects the distribution and abundance of many other species; a species whose impact is large and disproportionately large relative to its abundance.
Engineering Species (type of keystone)	Conserve populations	Other species' or populations	Organisms that directly or indirectly controls the availability of resources to other organisms by causing physical-state changes in biotic /abiotic materials. Example – North American beaver.
Other Types Of Surrogates			
Substitute Species	Assess other species' responses to environmental change	Behavior of other species	Their behavior is a marker for human-induced behavioral change in other species. Similar to cross-taxon response species.
Focal Species	Determine most limiting factors	Other species' populations	Often misused; not clearly defined. The species chosen provides a protective umbrella for other species.

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